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Total Maximum Daily Loads (TMDLs) for Petroleum Hydrocarbons in the Waters of Skagway Harbor in Skagway, Alaska

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Total Maximum Daily Load (TMDL) for Petroleum Hydrocarbons in Skagway Harbor, Alaska

TMDL AT A GLANCE:

Water Quality Limited?	Yes
Alaska ID Number:	10303-601
Criteria of Concern:	Petroleum Hydrocarbons
Designated Uses Affected:	Growth and propagation of fish, shellfish, other aquatic life, and wildlife.
Major Source(s):	Historical spills and current operations at docks and harbors
Loading Capacity:	4,022 µg/kg
Wasteload Allocation:	Not applicable
Load Allocation:	3,619.8 µg/kg
Margin of Safety:	Explicit 10 percent (402.2 µg/kg) and implicit assumptions
Necessary Load Reduction:	Varies by allocation area (see below)

Location	Total PAHs (µg/kg)					Percent Reduction
	Loading Capacity	WLA	LA	MOS	Maximum Observed	
West Harbor	4,022	N/A	3,620	402	13,779	71%
Central Harbor	4,022	N/A	3,620	402	6,902	42%

Executive Summary

Skagway Harbor is located at the northern end of the Lynn Canal and provides portage to the City of Skagway, Alaska. The harbor is located adjacent to the mouth of the Skagway River and is formed by a small peninsula that separates the harbor from where the river empties into the Taiya Inlet, which opens to the Lynn Canal. The harbor was initially constructed in the early 1900s and was expanded off and on through dredge and fill operations reaching its current configuration in the late 1960s. Skagway Harbor is divided into three general areas. The west harbor includes the Ore Dock, central harbor includes the Broadway Dock and the adjacent State Ferry Dock, and the east harbor includes the Small Boat Harbor and adjacent White Pass Railroad Dock. The only natural drainage directly into Skagway Harbor is Pullen Creek, which runs along and over the southern boundary of the City of Skagway. Approximately 2.1 miles long, the creek's headwaters begin in the rail yard at the northeast end of town and confluence with Skagway Harbor near the Broadway Dock.

Shipping operations in Skagway Harbor have historically centered on the mining activities in the region. During its period of operation as a shipping hub for regional mining operations, metal ores were transported through the City of Skagway by rail and offloaded onto freighters and barges stationed in the harbor. The transfer of lead and zinc ores from the Yukon to Skagway by railroad began in the mid-1920s and, except for periods of inactivity between 1982-1986 and 1993-1994, continued until 1997. Currently, harbor traffic is dominated by summer cruise ships and ferries.

Alaska Department of Environmental Conservation (ADEC) originally placed Skagway Harbor on Alaska's 1990 Section 303(d) list due to sediment toxicity from metals. ADEC found high concentrations of lead, zinc, cadmium, copper, and mercury in harbor sediments; the reduced infauna diversity initially correlated with sediment lead and zinc concentrations prompting ADEC to list this water for non-attainment of the aquatic life designated use.

Numerous organizations and agencies have monitored surficial sediment concentrations in Skagway Harbor in the last three decades, with the monitoring primarily focused on metals contamination. Due to the age of these studies (some of them are more than 20 years old) and the focus of these studies on a particular location, EPA and DEC conducted sampling in 2007 to characterize current sediment and water quality throughout Skagway Harbor, including toxicity testing (Tetra Tech 2008). While some harbor sediment samples exhibited elevated concentrations of metals (e.g., zinc, lead), this study showed concentrations at orders of magnitudes lower than in previous investigations. In addition, analysis of acid volatile sulfides (AVS) to metals ratio and sediment toxicity identification evaluation (TIE) indicated that metals were not expected to be the cause of toxicity. Based on the observation of oil sheens and odors in sediment samples, ADEC and EPA theorized that petroleum derivatives are a probable source of the sediment toxicity (Tetra Tech 2008).

ADEC and EPA conducted a follow-up study in 2008 to further evaluate petroleum derivatives as the cause of sediment toxicity in the harbor (Tetra Tech 2009). This study measured semi-volatiles (polycyclic aromatic hydrocarbons [PAH]) and total petroleum hydrocarbons (TPH) in both sediment and surface water in the harbor and volatile organic compounds (VOC) and oil and grease in surface water. The levels of petroleum derivatives found in Skagway Harbor sediments were, in most cases, above the National Oceanic and Atmospheric Administration (NOAA) chronic sediment quality guideline and in some cases exceeded the NOAA acute sediment quality guideline, although they were not detected in the water column. ADEC concluded that the high concentrations of petroleum derivatives found in the Skagway Harbor sediments are the probable cause for the sediment toxicity observed in 2007.

Although ADEC does not know definitely what is causing the petroleum impairments in Skagway Harbor, the following are potential sources of the impairment. Dock operations, including fueling, bilge pumping, underwater exhaust, and leaking stern tubes, shafts, stabilizers, and thrusters might be contributing to the petroleum impairments. Activities associated with the historic fuel pipeline and railroad operations also may have contributed to petroleum impairments. Numerous petroleum contaminated sites are also located throughout the City of Skagway, though there is only one documented case of a significant spill to surface water. In addition, the tributary to the harbor (Pullen Creek) might be contributing petroleum contaminants to the harbor.

This Total Maximum Daily Load (TMDL) is established to meet the requirements of Section 303(d)(1) of the Clean Water Act. A TMDL represents the amount of a pollutant the waterbody can receive while maintaining compliance with applicable water quality standards. A TMDL is composed of individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background loads. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody.

Because it is assumed that the sediment toxicity impairment is caused by levels of petroleum in harbor sediments, the TMDL establishes limits for total PAHs. ADEC developed the TMDL using applicable marine water quality criteria for petroleum hydrocarbons and oil and grease that state “there may be no concentrations of petroleum hydrocarbons, animal fats, or vegetable oils in shoreline or bottom sediments that cause deleterious effects to aquatic life.” Because these criteria are narrative, ADEC used the numeric toxicological screening criteria presented in the NOAA *Screening Quick Reference Tables* (Buchman 2008) to establish the numeric target for this TMDL.

For the petroleum hydrocarbon TMDL target, ADEC used the toxicity limit known as the Effects Range-Low (ERL). The ERL represents the chemical sediment concentration at which toxic effects might begin to be observed in sensitive species. ERL guidelines are available for PAHs in marine sediment. Petroleum contamination in water is often assessed as total aqueous hydrocarbon (TAqH) concentrations, which is the sum of PAHs and total aromatic hydrocarbons (TAH) concentrations, but TAHs are rarely observed in sediments due to their volatility (Tetra Tech 2009).

The TMDL establishes the LA in Skagway Harbor as the ERL minus 10 percent for the margin of safety. The development of WLAs was not applicable to the study area because there are currently no permitted discharges of petroleum hydrocarbons to the harbor.

The TMDL recommends consistent development and application of best management practices (BMPs) at docks to minimize the potential for fuel and oil spills in the study area. In addition, monitoring should continue to determine whether natural recovery is occurring and concentrations of petroleum contaminants are decreasing over time due to natural sedimentation processes. Monitoring will allow ADEC to track the progress of changes in water and sediment and determine whether acceptable progress is being made. Monitoring also could include further evaluation of potential stormwater sources and use of bioassays to determine whether petroleum impacted sediments are having a deleterious effect on benthic communities.

1. Overview

Section 303(d)(1)(C) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) implementing regulations (40 CFR Part 130) require the establishment of a Total Maximum Daily Load (TMDL) for the achievement of state water quality standards when a waterbody is water quality-limited. A TMDL identifies the amount of a pollutant that a waterbody can assimilate and maintain compliance with water quality standards. TMDLs include an appropriate margin of safety and identify the level of pollutant control needed to reduce pollutant inputs to a level (or "load") that fully supports the designated uses of a given waterbody. The mechanisms used to address water quality problems after the TMDL is developed can include a combination of best management practices (BMPs) for nonpoint sources and/or effluent limits and monitoring required through National Pollutant Discharge Elimination System (NPDES) permits.

Skagway Harbor is located at the northern end of the Lynn Canal and serves the City of Skagway, Alaska. The harbor is located adjacent to the mouth of the Skagway River and is formed by a small peninsula that separates the harbor from where the river empties into the Taiya Inlet, which opens into the Lynn Canal.

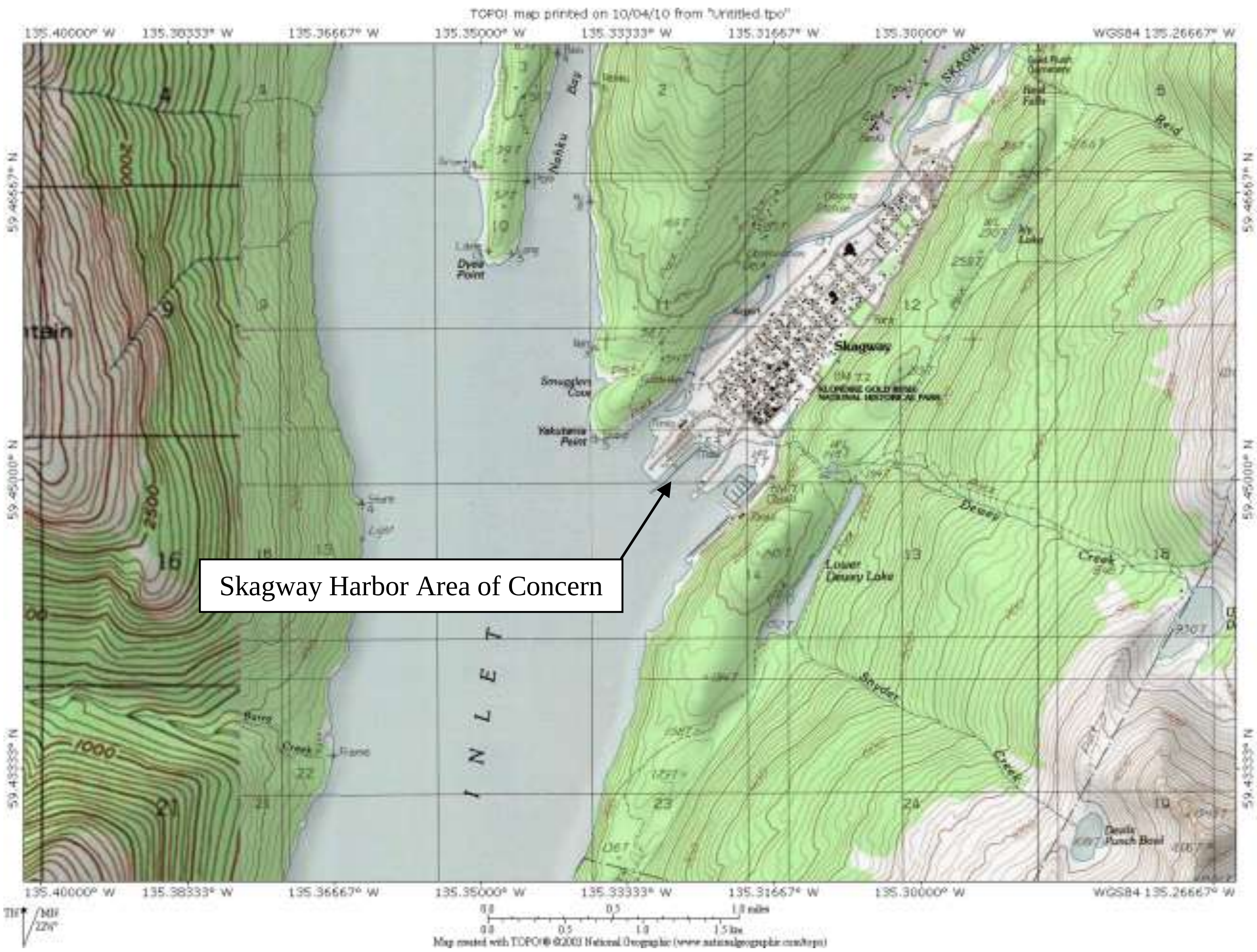

Figure 1-1. Study area general location

This document summarizes the available monitoring and pollutant source data for Skagway Harbor and presents TMDLs to address impairments related to sediment toxicity.Alaska Department of Environmental Conservation (ADEC) placed Skagway Harbor on their 1990 Section 303(d) list due to sediment toxicity. ADEC found high concentrations of lead, zinc, cadmium, copper, and mercury in harbor sediments; the reduced infauna diversity initially correlated with sediment lead and zinc concentrations, prompting ADEC to list the harbor for non-attainment of the aquatic life designated use.

While the original listing for sediment toxicity was expected to be the result of metals contamination, more recent monitoring of the harbor conducted for ADEC has found that sediment toxicity impairments are most likely due to petroleum hydrocarbon contamination. Recent monitoring shows levels of metals in harbor sediments substantially lower than levels measured in the 1980s and 1990s. Because the primary source of metals (i.e., ore transfer and transport activities) is no longer active, it is expected that the metals sediment levels will continue to decrease. Because monitoring during 2007 and 2008 observed oil sheens in sediment samples and measured PAH levels above screening guidelines, it is assumed that the current sediment toxicity impairment is the result of petroleum products in the harbor sediments. While petroleum products are expected to be the cause of sediment toxicity, future management should still consider metals as a potential threat to the harbor.

Table 1-1 summarizes the information included in Alaska's approved 2010 303(d) list for Skagway Harbor. Note that the listing does not yet reflect the determination that sediment toxicity in Skagway Harbor is the result of petroleum hydrocarbon derivatives. The TMDL target and allocations will be based on establishing levels of petroleum hydrocarbons that will not result in sediment toxicity and will maintain water quality standards.

Table 1-1. Summary of 303(d) listing information for Skagway Harbor from ADEC's 2010 Integrated Report

<table>
<tr><th>Alaska ID Number</th><th>Waterbody</th><th>Area of Concern</th><th>Water Quality Standard</th><th>Pollutant Parameters</th><th>Pollutant Sources</th></tr>
<tr><td>10303-601</td><td>Skagway Harbor</td><td>1.0 acre</td><td>Toxic & Other Deleterious Organic and Inorganic Substances</td><td>Metals</td><td>Industrial</td></tr>
<tr><td colspan="6">Skagway Harbor has been on the Section 303(d) list since 1990 for non-attainment of the toxic and other deleterious organic and inorganic substances standard for metals. A 1984 draft report from USF&WS titled Trace Metals Contamination at an Ore Loading Facility in Skagway, Alaska, indicated that trace metals contamination is due to an ore loading facility in Skagway. Elevated levels of lead, zinc, cadmium, copper, and mercury in marine sediments were found to exceed DEC (SPAR) values of the control area. Additionally, in fauna found in the marine sediments were much reduced and a reduction in fauna and biodiversity was correlated with concentrations of lead and zinc in marine sediment. These effects are considered to be an impairment to the designated use: aquatic life. Additional sampling in 2008 found metals in the marine sediment to be below recommended action levels and petroleum constituents above action levels. A TMDL is being prepared to address the impairment.</td></tr>
</table>

2. Watershed Background

2.1. Location and Physical Setting

Skagway Harbor serves the City of Skagway located in the Skagway River Valley, which is approximately two miles long and is surrounded by the heavily forested mountain terrain of Tongass National Forest. Vegetation within and surrounding Skagway varies with elevation and soil type, ranging from coastal rainforest to boreal and sub-alpine forests. The city is bordered by the Skagway River to the north, which empties into the Taiya Inlet at the northern end of the Lynn Canal approximately 113 miles northwest of Juneau, Alaska. The Alexander Archipelago, a dense grouping of islands created by the tops of the submerged coastal mountains, separates the City of Skagway from the Gulf of Alaska. The islands of the archipelago are highly mineralized and characterized by irregular steep coasts that create deep channels and fjords (Skagway Traditional Council 2005).

Taiya Inlet, like the archipelago that surrounds it, is an area of deep bays and channels bordered by steep sided mountains formed by past glacial and volcanic activity. The transition from open water to upland areas is characterized by dramatic changes in water depth. Within 500 meters offshore of Skagway Harbor water depths exceed 90 meters (300 feet). Depths within the harbor, however, range between 6 and 8 meters (10 and 30 feet). Tidal fluctuation in the harbor can exceed 5 meters, but typically are within 4.25 meters (14 feet). These conditions suggest that water moves quickly in and out of the harbor (Skagway Traditional Council 2005).

The harbor itself is located adjacent to the mouth of Skagway River. A small peninsula approximately 150 meters in width currently separates the harbor from where the river empties into the Taiya Inlet, which opens into the Lynn Canal. The harbor was initially constructed in the early 1900s and was expanded off and on through dredge and fill operations reaching its current configuration in the late 1960s. Skagway Harbor is divided into three general areas (Figure 2-1). The west harbor includes the Ore Dock, the central harbor includes the Broadway Dock and the adjacent State Ferry Dock, and the east harbor includes the Small Boat Harbor and adjacent White Pass Railroad Dock. During its period of operation as a shipping hub for regional mining operations, mining ores were transported through the City of Skagway by rail and offloaded onto freighters and barges stationed at the harbor Ore Dock. The railroad transferred lead and zinc ores from the Yukon to Skagway, beginning in the mid-1920s and continuing through 1997, except for periods of inactivity between 1982-1986 and 1993-1994. Currently, harbor traffic includes summer cruise ships and ferries associated with the Alaska Marine Highway.

The Skagway Harbor watershed is approximately 6.2 square miles. The only drainage feeding directly into Skagway Harbor is Pullen Creek. The entire length (1.5 miles) of Pullen Creek runs along and over the southern boundary of the City of Skagway. Its headwaters begin in the rail yard at the northeast end of town and confluence with Skagway Harbor adjacent to the Broadway Dock. For much of its route it flows adjacent to the White Pass and Yukon Railroad, which borders the City of Skagway to the southeast. Two spring fed tributaries enter Pullen Creek along its length and it also receives inflows from Alaska Power and Telephone (APT) Dewey Lakes Hydroelectric plant (Skagway Traditional Council 2005). Pullen Creek provides over-wintering rearing habitat for coho and Dolly Varden and spawning habitat for coho, pink, and chum salmon (Skagway Traditional Council 2005).

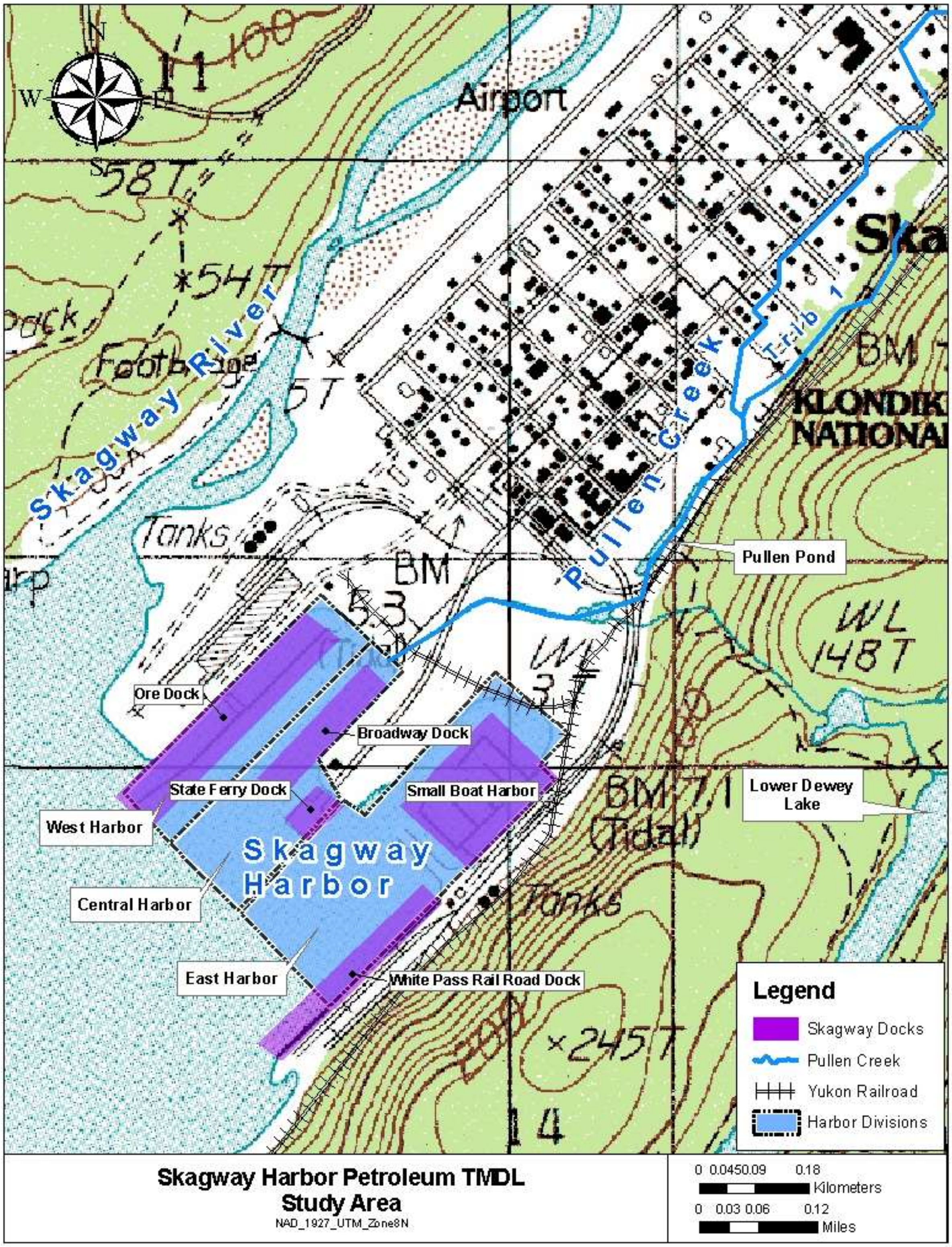

Figure 2-1. Skagway Harbor study area location

2.2. Climate

The City of Skagway is within the Alaskan maritime climate zone, which is characterized by cool summers and mild winters. Low-lying fog, overcast skies, rain, and drizzle dominate weather conditions due to air masses over the warmer Pacific Ocean mixing with chilled air over the colder Bering Sea. Average summer air temperatures range between 45 to 67 degrees Fahrenheit (F), while average winter temperatures range between 18 to 37 degrees F. Skagway receives less rain than is typical for Southeast Alaska. Precipitation in Skagway averages 26 inches of rain per year and 39 inches of snow per year (Skagway Traditional Council 2005).

2.3. Cultural and Economic History

Skagway is located within the traditional territory of the Chilkoot Band of the Tlingit Tribe. Skagway and its surrounding area were important historically as trade routes that ranged from the interior of Alaska and Canada to the tip of California. While what is known as the city of Skagway now was not occupied year-round, the neighboring community of Dyea was a permanent Tlingit village (Skagway Traditional Council 2005).

In 1896, the discovery of gold brought prospectors to settle in Skagway. Although the Klondike Gold Rush lasted only three years (1896–1899), it drew some 20,000 prospectors traveling through Skagway on their way to either the Chilkoot Pass or White Pass trail. In 1900, Skagway became Alaska’s first incorporated city. By then the gold rush years ended and, as a result, Skagway’s economy stabilized around the railroad industry. The town experienced an economic boom during World War II and Skagway became an important part of Alaska’s defense system. A fuel pipeline was built paralleling the railroad from Skagway to Whitehorse in the Yukon Territory of Canada during the war. The pipeline and the railroad were used to haul materials for the war effort and for the construction of the Alaska-Canada Highway (Skagway Traditional Council 2005).

With the opening of the Cyprus Anvil lead-zinc mine in Faro, Canada, Skagway experienced another economic boom during the late 1960s through the mid 1970s. Skagway’s freight shipments increased from 132,000 tons annually to 800,000 tons by the mid-1970s. The White Pass and Yukon Route (WP & YR) built an ore terminal and ship basin on city-leased tidelands to handle the increased capacity (currently known as the ore dock). As labor costs continued to increase and the market price for ore decreased after 1975, the mine closed in 1982. The railroad, which was dependent on the mine shipments, also shut down at that time (Skagway Traditional Council 2005).

After the initial closure of the mine in 1982, it was bought and sold multiple times leading to resumption of ore shipping activities, though on a much smaller scale, in the harbor between 1986 and 1997 except for a period of inactivity between 1993-1994. The Klondike Highway, which links Skagway and Whitehorse was completed in 1978 and became open year-round by 1986. At this time tourism began to play a more important role in the city’s economy (Skagway Traditional Council 2005). Mining related shipping operations in Skagway Harbor resumed in late 2007 after the Skagway Ore Terminal was reactivated by Alaska Industrial Development and Export Authority (AIDEA). According to AIDEA’s web site they are continuing active discussions with mining companies for potential use of the Skagway Ore Terminal.

Skagway is one of three Southeast Alaskan communities that are connected to the road system, allowing access to the lower 48, Whitehorse, the Yukon, northern British Columbia, and the Alaska Highway. This also makes Skagway an important port-of-call for the Alaska Marine Highway — Alaska’s ferry system

— and serves as the northern terminus of the important and heavily-used Lynn Canal corridor (Skagway Traditional Council 2005).

Currently the city is a tourist center and serves as an important trade route for Southeast Alaska. It currently hosts freight barges, ferries, cruise ships, water taxis, and fishing boats (Skagway Traditional Council 2005). For example, according to the cruise ship calendar on Skagway's web site, 27 cruise ships will dock in Skagway Harbor 373 times during the 2010 cruise ship season (May – September). As of the 2000 census, the population of the city was 862. However, the general population doubles in the summer tourist season with the arrival of seasonal employees to support more than 900,000 visitors each summer. The port of Skagway is a popular stop for cruise ships, and the tourist trade is a big part of the business of Skagway. The White Pass and Yukon Route narrow gauge railroad, part of the area's mining past, is now in operation only for the tourist trade and runs throughout the summer months.

3. Water Quality Standards and TMDL Target

Water quality standards designate the "uses" to be protected (e.g., water supply, recreation, aquatic life) and the "criteria" for their protection (e.g., how much of a pollutant can be present in a waterbody without impairing its designated uses). TMDLs are developed to meet applicable water quality standards, which include numeric water quality criteria or narrative criteria for the support of designated uses. The TMDL target identifies the numeric goals or endpoints for the TMDL that equate to attainment of the water quality standards. The TMDL target may be equivalent to a numeric water quality criterion where one exists, or it may represent a quantitative interpretation of a narrative criterion, which is the case in this TMDL. This section reviews the applicable water quality standards and identifies an appropriate TMDL target for calculation of the petroleum TMDLs to address impairment by sediment toxicity in Skagway Harbor.

3.1. Applicable Water Quality Standards

Title 18, Chapter 70 of the Alaska Administrative Code (ACC) establishes water quality standards for the waters of Alaska, including the designated uses to be protected and the water quality criteria necessary to protect the uses. State water quality criteria are defined for both marine and fresh waterbodies. Skagway Harbor is subject to marine water requirements.

Designated uses established in the State of Alaska Water Quality Standards (18 AAC 70) for marine waters of the state include (1) water supply, (2) water recreation, (3) growth and propagation of fish, shellfish, other aquatic life, and wildlife, and (4) harvesting for consumption of raw mollusks or other raw aquatic life and are applicable to all marine waters, unless specifically exempted. Table 3-1 lists water quality criteria for petroleum hydrocarbons, oils and grease for marine waters applicable to Skagway Harbor impairments.

Table 3-1. Marine water quality criteria for petroleum hydrocarbons, oils and grease (18 AAC 70.020)

Designated use	Description of criteria
(17) Petroleum hydrocarbons, oils and grease, for marine water uses	
(A) Water Supply	
(i) aquaculture	Total aqueous hydrocarbons (TAqH) in the water column may not exceed 15 µg/L (see note a). Total aromatic hydrocarbons (TAH) in the water column may not exceed 10 µg/L. There may be no concentrations of petroleum hydrocarbons, animal fats, or vegetable oils in shoreline or bottom sediments that cause deleterious effects to aquatic life. Surface waters and adjoining shorelines must be virtually free from floating oil, film, sheen, or discoloration.
(ii) seafood processing	May not cause a film, sheen, or discoloration on the surface or floor of the waterbody or adjoining shorelines. Surface waters must be virtually free from floating oils. May not exceed concentrations that individually or in combination impart odor or taste as determined by organoleptic tests.
(iii) industrial	May not make the water unfit or unsafe for the use.
(B) Water Recreation	
(i) contact recreation	May not cause a film, sheen, or discoloration on the surface or floor of the waterbody or adjoining shorelines. Surface waters must be virtually free from floating oils.
(ii) secondary recreation	Same as (17)(B)(i) - contact recreation

Designated use	Description of criteria
(C) Growth and propagation of fish, shellfish, other aquatic life, and wildlife	Same as (17)(A)(i) - aquaculture
(D) Harvesting for Consumption of Raw Mollusks or Other Raw Aquatic Life	May not exceed concentrations that individually or in combination impart undesirable odor or taste to organisms as determined by bioassay or organoleptic tests.

3.2. Sediment Quality Targets

Petroleum hydrocarbon derivatives in sediments are causing the impairments in Skagway Harbor. To date, ADEC has not adopted numeric sediment quality standards for the evaluation of impacts to aquatic life. However, the ADEC Contaminated Sites Remediation Program has issued the technical memorandum *Sediment Quality Guidelines* (ADEC 2004), which recommends using the "effects" levels available as sediment quality guidelines and presented in the *NOAA Screening Quick Reference Tables* (Buchman 2008). The effects levels are generally statistically derived from database information of sediment contamination levels and corresponding biological responses of benthic organisms. Biological responses might be field observations or laboratory derived. Several different databases and statistical approaches have been employed to develop "effects" levels, a lower level below which benthic effects are not expected to occur and a higher level above which effects are frequently expected. These screening levels have been statistically derived for a wide range of chemicals and generally, are better suited for evaluating sediments containing a mixture of contaminants (ADEC 2004).

Screening levels presented in Buchman (2008) include Threshold Effects Level (TEL), Effects Range-Low (ERL), and Probable Effects Level (PEL) for evaluating sediment quality. The thresholds represent screening concentrations used as benchmarks to assess whether concentrations of various contaminants have a probability of adverse biological effects. TELs define chemical sediment concentrations below which toxic effects are rarely observed in sensitive species, while PELs define concentrations above which effects are frequently or always observed. The ERL threshold is greater than the TEL but less than the PEL and is calculated as the lower 10th percentile concentration of those samples identified as toxic in the original sediment toxicity studies. The ERL represents the chemical sediment concentration at which toxic effects might begin to be observed in sensitive species. Table 3-2 presents TELs, ERLs, and PELs applicable to petroleum hydrocarbon contamination, as provided in the *NOAA Screening Quick Reference Tables* (Buchman 2008).

Table 3-2. Marine water sediment quality screening levels for petroleum hydrocarbon pollutants

Compound	TEL (µg/kg)	ERL (µg/kg)	PEL (µg/kg)
Acenaphthene	6.71	16	88.9
Acenaphthylene	5.87	44	127.87
Anthracene	46.85	85.3	245
Benzo(a)pyrene	88.81	430	763.22
Benzo(a)anthracene	74.83	261	692.53
Chrysene	107.77	384	845.98
Dibenzo(a,h)anthracene	6.22	63.4	134.61
Fluoranthene	112.82	600	1,493.54
Fluorene	21.17	19	144.35
Naphthalene	34.57	160	390.64

Compound	TEL (µg/kg)	ERL (µg/kg)	PEL (µg/kg)
Phenanthrene	86.68	240	543.53
Pyrene	152.66	665	1,397.6
Total PAHs[1]	1,684.06	4,022	16,770.4

Source: Buchman (2008)

3.3. Impairments

ADEC listed Skagway Harbor on their 1990 Section 303(d) list due to sediment toxicity potentially due to metals and expected to be causing the observed reduced number and diversity of infauna found in the marine sediments. Recent monitoring conducted for ADEC in 2007 and 2008 confirmed the toxicity in the harbor sediments but concluded that it is not the result of metals (Tetra Tech 2008, 2009). The monitoring data also show levels of metals in harbor sediments substantially lower than levels measured in the 1980s and 1990s. Because the primary source of metals (i.e., ore transfer and transport activities) is no longer active, it is expected that the metals sediment levels will continue to decrease. Observations of sheens and odors in sediment samples collected during the 2007 monitoring led to follow up monitoring in 2008 to further evaluate potential impairment from petroleum products. The 2008 sampling study found concentrations of polycyclic aromatic hydrocarbons (PAHs) in sediments at levels shown to cause toxicity (Tetra Tech 2009). Because of the observed oil sheens in sediment samples and the measured PAH levels above screening guidelines during the 2007 and 2008 monitoring, ADEC assumes that the current sediment toxicity impairment is the result of petroleum products in the harbor sediments. (It should be noted that water samples collected in the harbor met applicable water quality criteria for TAqH and TAH in the water column.) ADEC has therefore concluded that the development of a TMDL for petroleum hydrocarbons is the most appropriate approach for addressing sediment toxicity impairments in the harbor.

The current impaired status of Skagway Harbor is based on exceedances of the narrative provisions of the Water Supply and Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife water quality criteria, which state “there may be no concentrations of petroleum hydrocarbons, animal fats, or vegetable oils in shoreline or bottom sediments that cause deleterious effects to aquatic life.”

Although ADEC does not know what is causing the petroleum impairments in Skagway Harbor, the following sources could potentially contribute to the impairment. Historic spills or current activities at dock operations, including fueling and bilge pumping activities, could be contributing to the petroleum impairments. Numerous petroleum contaminated sites are also located throughout the City of Skagway, though there is only one case of a significant spill to surface water in the data record. In addition, monitoring in 2008 indicated elevated PAHs in creek sediments at the most downstream site. It is suspected that the sediment in the downstream portion of Pullen Creek might act as a sink, trapping the PAHs under normal conditions (Tetra Tech 2009). Therefore, Pullen Creek sediments have the potential to be a source of PAHs to Skagway Harbor, particularly if the sediments are disturbed.

3.4. TMDL Target

The TMDL target is the numeric endpoint used to evaluate the loading capacity and necessary load reductions and represents attainment of applicable water quality standards. The listed impairment of sediment toxicity in Skagway Harbor is presumed to be caused by elevated concentrations of petroleum hydrocarbons in the bottom sediments. Therefore, to address the impairment in the harbor the TMDL

[1] Note that this table does not list all PAH constituents that may be included in a measure of *Total PAHs*

establishes targets for acceptable levels of petroleum products in stream bottom sediments to support designated uses. The numeric sediment quality target represents conditions under which Skagway Harbor will meet applicable water quality standards. Because Alaska water quality standards include only narrative criteria related to sediment quality, it is necessary to identify an appropriate numeric sediment quality target that meets water quality standards and supports designated uses.

The ADEC Contaminated Sites Remediation Program has issued a technical memorandum *Sediment Quality Guidelines* (DEC 2004), which recommends using statistically derived "effects" levels for evaluating sediment quality. TELs define chemical sediment concentrations below which toxic effects are rarely observed in sensitive species, while PELs define concentrations above which effects are frequently or always observed. ERLs fall between the TEL and PEL for the respective contaminant and represent the chemical sediment concentration at which toxic effects might begin to be observed in sensitive species. For the Skagway Harbor TMDL, ADEC has selected the ERL as an appropriate target because it represents a sediment quality concentration below which minimal effects on aquatic life are expected.

Petroleum contamination in water is often assessed as total aqueous hydrocarbon (TAqH) concentrations, which is the sum of PAHs and total aromatic hydrocarbons (TAH) concentrations. However, TAHs are rarely observed in sediments due to their volatility. Therefore, ADEC selected total PAHs as the target parameter for calculating the Skagway Harbor petroleum hydrocarbon TMDLs. The ERL of 4,022 µg/kg for Total PAHs is used as the TMDL target (Table 3-2). ADEC believes that meeting the ERL will result in sediment conditions that will support water quality standards, including applicable designated uses.

4. Data Review

The following sections present the available monitoring data for Skagway Harbor. The data have been divided into two sections: 1) metals monitoring and 2) petroleum derivatives monitoring. Prior to monitoring conducted in 2007, ADEC assumed that the sediment toxicity impairments in the harbor were the result of metals contamination caused by historical mining ore shipping operations. Therefore, studies up until that time focused almost exclusively on metals contamination in the harbor. ADEC first hypothesized that toxicity in harbor sediments could be due to petroleum hydrocarbons in 2007 when oil sheens and odors were observed in sediment samples. Monitoring conducted in 2008 confirmed elevated levels of petroleum hydrocarbons in harbor sediments. This section summarizes available monitoring data for Skagway Harbor for metals and petroleum hydrocarbons. The section on metals is included to highlight the changes in metals contamination and how metals monitoring led to the discovery of elevated petroleum hydrocarbons and the assumption that petroleum hydrocarbons in the sediments are now the cause of the sediment toxicity in Skagway Harbor rather than the presence of metals.

4.1. Metals Monitoring

Previous studies of Skagway Harbor have focused on metals contamination due to historical mining ore shipping operations in the area. Surficial sediment and surface water concentrations have been measured in Skagway Harbor several times in the last three decades. Historical records indicate ten sampling events that include metals monitoring in surface water or sediments. Relevant reports are listed in Table 4-1. A brief summary of these reports and associated data is provided in this section.

Table 4-1. Summary of Skagway Harbor metals monitoring reports

Report Name	Publisher (abbreviation)	Publish Date	Data Type
Evaluation of Metals and Petroleum Derivatives in Skagway Harbor and Pullen Creek Sediments and Surface Waters	Tetra Tech Inc. (TT 2008)	Feb 2009	Surface water
Evaluation of Skagway Harbor and Pullen Creek Sediments and Surface Waters	Tetra Tech Inc. (TT 2007)	Feb 2008	Surficial sediments; surficial sediment and surface water toxicity; surface water; and fish tissue
Report Environmental Monitoring Skagway Ore Terminal Skagway, Alaska URS Job No. 26219771	URS, Inc. (URS 2006)	June 2006	Soils ; surficial sediment; and core sediment
Final Report Dredge Material Characterization and Geotechnical Evaluation Broadway Dock Expansion Skagway, Alaska	Petratrovich, Nottingham, and Drage, Inc. (PND 2005)	Jan 2005	Surficial sediment
Sediment Characterization and Analysis for Proposed Dredging and Deepwater Disposal at Broadway Dock - DA R-870590	Petratrovich, Nottingham, and Drage, Inc. (PND 1999)	Jan 1999	Surficial sediment
Final Environmental Site Assessment Report for the Skagway Ore Terminal for Alaska Industrial Development and Export Authority	Dames & Moore (DM 1995)	Nov 1995	Soils; surficial sediment; surface water; and fish tissue
Skagway Harbor Field Investigation	Tetra Tech Inc. (TT 1990)	Feb 1990	Surficial sediment; surface water; and fish tissue
Report No. 60608/1 Skagway Ore Shiploading Terminal	Steffen, Robertson, and Kirsten Inc. (SRK 1989)	Mar 1989	Soils; surficial Sediment; air quality; and groundwater

Report Name	Publisher (abbreviation)	Publish Date	Data Type
Technical Review of Water Quality and Biological Conditions in the Vicinity of the Skagway (AK) Municipal Outfall	Tetra Tech Inc. (DST 1985)	Sept 1988	Surficial sediment and fish tissue samples collected as part of a study by Dobrocky Seatech, Inc. (1985).
Trace Metals Contamination at an Ore Loading Facility in Skagway, Alaska. Prepare for USFWS, Juneau, Alaska.	Robinson-Wilson and Malinkey (RWM 1982)	1982	Surficial sediment; surface water; fish tissue; and species diversity/abundance survey

Sediment Monitoring

As mentioned above, previous monitoring studies in Skagway Harbor have focused on metals contamination, particularly lead and zinc, in sediments located in the vicinity of Ore and Broadway Dock. In addition, there was historical concern that surface water metals concentrations might be exceeding applicable water quality standards. Marine water quality criteria and sediment screening levels for metals are shown in Table 4-2.

Table 4-2. Marine water quality criteria and sediment quality thresholds for metals[2]

Metal	Water quality criteria		Sediment quality thresholds		
	Acute criterion (CMC; µg/L)	Chronic criterion (CCC; µg/L)	NOAA-TEL (mg/kg)	NOAA-ERL (mg/kg)	NOAA-PEL (mg/kg)
Barium	--	--	--	--	--
Cadmium	40	8.8	0.676	1.2	4.21
Copper	4.8	3.1	18.7	34	108.2
Lead	210	8.1	30.24	46.7	112.18
Mercury	1.8*	0.94*	0.13	0.15	0.696
Nickel	74	8.2	15.9	20.9	42.8
Zinc	90	81	124	150	271

***** This criterion was derived from data for inorganic mercury (II)

The discussion in this section focuses on the 2007 sediment-related data that led to the 2008 monitoring study and related determination that Skagway Harbor sediment toxicity impairments are being caused by petroleum hydrocarbon contamination.

Throughout the monitoring record of Skagway Harbor, sediment samples have been collected at multiple locations throughout the harbor, although rarely in the exact the same location. To simplify the analysis of sediment quality trends, the data are grouped by general areas in the harbor. These areas, depicted in Figure 2-1, include the 1) West Harbor in the vicinity of the Ore Dock, 2) Central Harbor that includes the Broadway/Ferry Dock, and 3) East Harbor, which represents the area east of the Ferry dock and includes the Small Boat Harbor and the White Pass Railroad Dock.

[2] The state of Alaska has adopted the U.S. Environmental Protection Agency's (USEPA) water quality criteria for priority and non-priority pollutants. Alaska's water quality criteria are based on the dissolved (biologically active) fraction of metal concentration in ambient water. Criteria are developed to protect aquatic life and consist of two classifications, Criteria Maximum Concentration (CMC) and Criterion Continuous Concentration (CCC). CMC is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. CCC is an estimate of the highest concentration of a material in surface water to which and aquatic community can be exposed indefinitely without resulting in an unacceptable effect. The definition of sediment TELs and PELs are the same as those given in Section 3.2.

Figure 4-1 presents the historical monitoring results for lead, zinc, cadmium, mercury, and nickel in harbor sediments. The data are grouped by general harbor area and the mean and range of the data are given. Much of the historic monitoring focused on lead, zinc, and copper due to their presence in the mining ores transported to and shipped from the harbor.

Concentrations measured in the past decade are consistently lower throughout the harbor than those measured in the 1980s and 1990s. The major source of metals contamination in the area was the activities related to ore transportation and transfer. Because the mine and related activities have ceased it is likely that the metals levels in the harbor have continued to decrease without an active source of metals. The sediment concentrations could be decreasing over time because historically accumulated metals in the sediments are being flushed out of the harbor or being buried by cleaner sediment. The physiography of the harbor is characterized by steep submarine slopes and a small near-shore region that combined with natural phenomena such as tectonic uplift and asymmetrical tidal currents could favor the flux of sediment away from the harbor and down into the Lynn Canal (Gubala 2007). In addition, the 2007 study noted that it was not unusual for the study reference site to exhibit as high or higher sediment concentrations for some metals as harbor samples. This suggests that current concentrations of some metals in the harbor are similar to the natural condition in the region (Tetra Tech 2008).

While some recent sediment samples have metals concentrations above ERLs, toxicity testing during 2007 monitoring indicated that sediment toxicity is not likely due to metals concentrations. Analysis of acute toxicity was performed for surface water, sediment pore water and sediment samples collected as part of the 2007 study (Figure 4-2). The toxicity of all media was assessed using survival and growth rates of selected benthic and pelagic fauna. Of the seven sediment samples collected, four harbor sites (SH-7, SH-10, SH-11 and SH-12) and the reference site showed acute toxicity for both sediment and pore water samples (Tetra Tech 2008). Up until the 2007 monitoring study, ADEC had assumed that toxicity in harbor sediment was related to historical metals contamination. To test whether metals concentration in sediments was the cause of sediment toxicity, two tests were performed: toxicity identification evaluation (TIE) testing and analysis of acid volatile sulfide concentrations (AVS). Metals:AVS ratios that are < 1.0 indicate there is little or no potential for metals to be bioavailable in the pore water because they are bound to sediment sulfides. Thus, metals are generally incapable of being toxic in sediments under these conditions. TIE analyses includes manipulation of a sample to negate the effects of certain stressors to determine if these are in fact the source of toxicity, in this case metals (Tetra Tech 2008).

Monitoring of AVS in harbor sediments and TIE analyses both indicated that metals are not likely the source of toxicity. The concentration of AVS present in harbor sediments was often < 1.0, and therefore metals were generally not bioavailable in the study area. Results of the TIE analysis indicated that metals were bound by the added ethylene-diaminetetraacetic acid (EDTA) treatment and therefore non-toxic, yet toxicity was still exhibited in the samples tested. Finally, species-specific toxicity values for Mysid shrimp and other species tested indicate that the metal concentrations observed in pore waters are well below levels reported to be chronically toxic (Tetra Tech 2008). Therefore, ADEC concluded that a stressor or pollutant other than metals is likely causing toxicity in the harbor sediments.

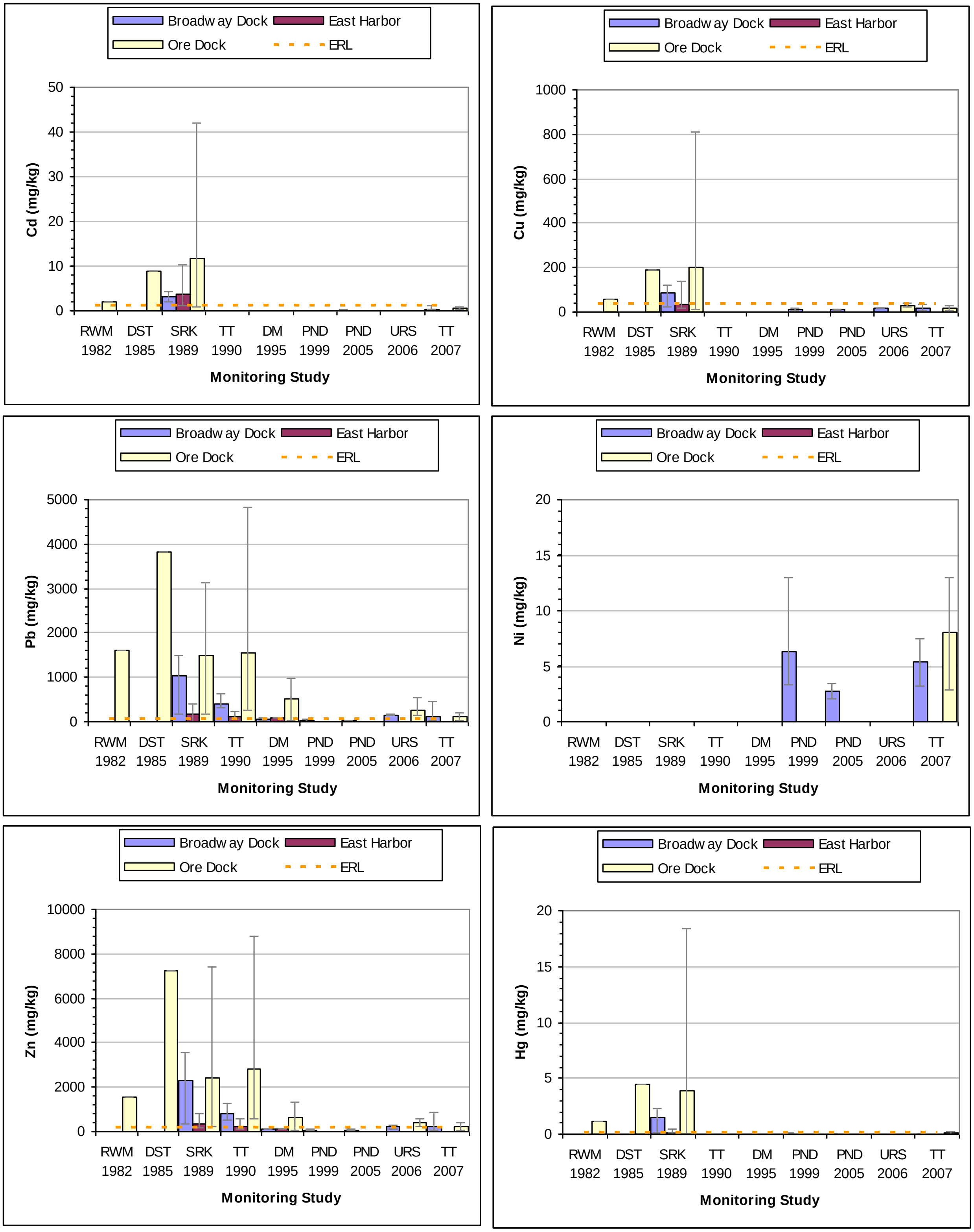

Figure 4-1. Summary of metals concentrations in harbor sediments measured during historical and recent monitoring studies

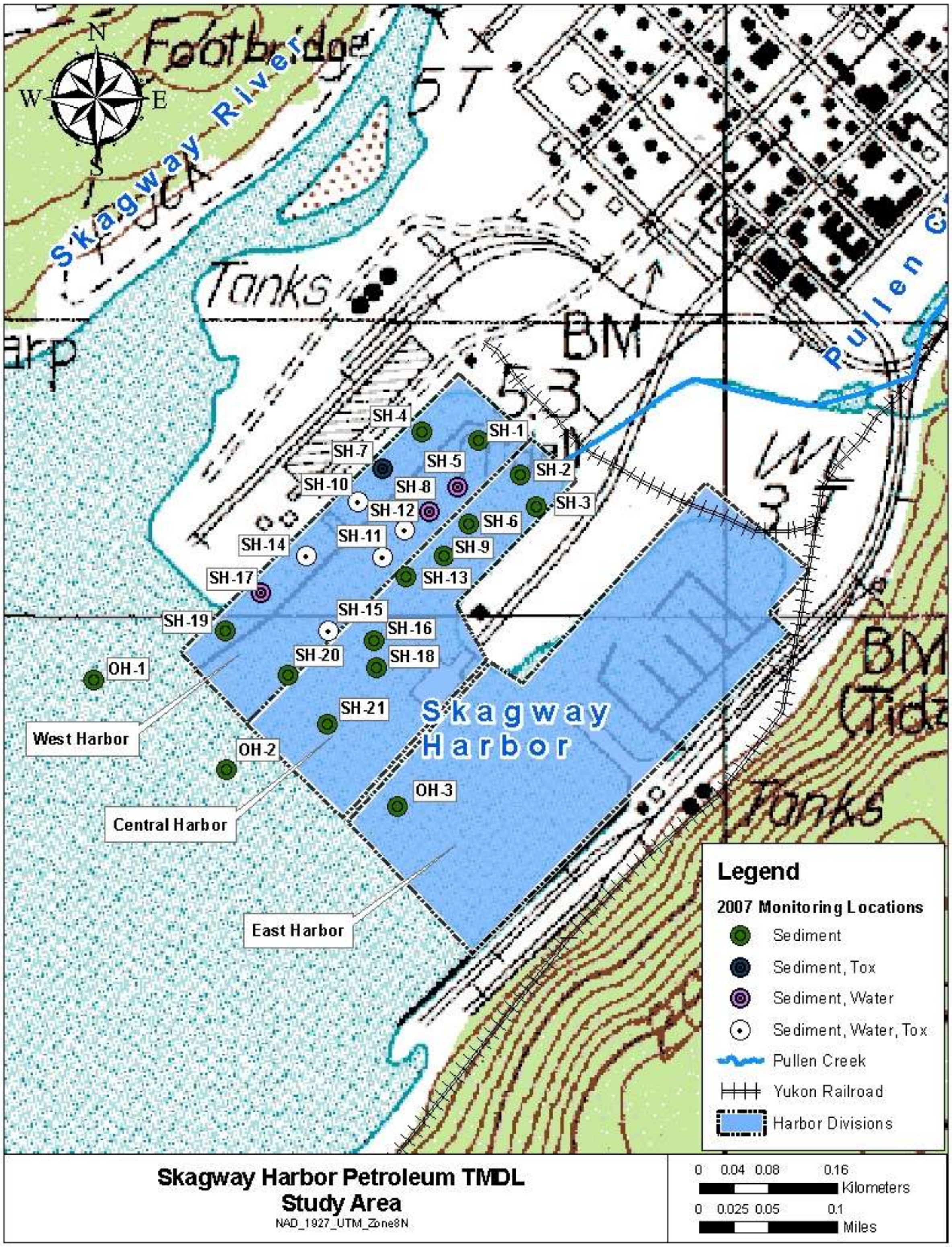

Figure 4-2. Skagway Harbor 2007 sediment, water column, and toxicity monitoring locations

Water Column

Water column metals concentrations were measured as part of five different monitoring studies in Skagway Harbor—Robinson-Wilson and Malinkey (1982), Tetra Tech (1990), Dames & Moore (1995), Tetra Tech (2008), and Tetra Tech (2009). In general, the available surface water monitoring data is fairly limited. In the 1995 Dames & Moore study, all results (lead and zinc) were reported as non-detect. The 1990 Tetra Tech study consisted of a single surface water sample collected in the Small Boat Harbor and analyzed for dissolved lead, with the reported concentration (61.4 µg/L) exceeding the applicable chronic criteria (8.1 µg/L). The 1982 Robinson-Wilson and Malinkey study also included only one sample, which was collected by the Ore Dock and analyzed for copper, lead and mercury. All concentrations were reported below applicable water quality criteria.

The most robust surface water quality dataset is available from the 2007 monitoring study conducted for ADEC and EPA (Tetra Tech 2008). Table 4-3 presents a summary of the 2007 monitoring results for the targeted metals (lead, zinc, copper, nickel, cadmium, and mercury). All samples were collected in the vicinity of the Ore Dock. The majority of locations sampled had metals concentrations below the applicable water quality criteria. The only metal found to be above criteria was copper, with one sample (SH-5) having a concentration slightly above the acute criteria of 4.8 µg/L. Concentrations at four other stations were measured above the chronic criteria of 3.1 µg/L. Note that the monitoring concentrations used for comparison to applicable water quality criteria were for total recoverable metals, rather than the dissolved fraction, on which the criteria are based. This is because analytical results, in most cases, reported dissolved fraction concentrations greater than the total recoverable concentrations. In addition, like for sediment metals concentrations observed during the 2007 study, it was not unusual for the study reference site (REF), to exhibit as high or higher concentrations for some metals as harbor samples suggesting that metals in the harbor are similar to the natural condition in the region (Tetra Tech 2008).

Table 4-3. Water column total recoverable metals concentrations measured during 2007

Station	Location	Depth	Cadmium (µg/L)	Copper (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)
SH-5	Ore Dock	Surface	ND (0.16)	**4.9**	3.2	ND (0.092)	ND (1.7)	37
SH-8	Ore Dock	Surface	ND (0.16)	2.8	ND (0.76)	ND (0.055)	ND (1.2)	19
SH-10	Ore Dock	Surface	ND (0.16)	**3.4**	3.3	ND (0.055)	ND (1.2)	67
SH-11	Ore Dock	Surface	ND (0.16)	2.8	ND (0.6)	ND (0.059)	ND (1.1)	12
SH-12	Ore Dock	Surface	ND (0.16)	**3.4**	5.4	ND (0.055)	ND (0.99)	62
SH-14	Ore Dock	Surface	ND (0.16)	**3.2**	2.1	ND (0.13)	ND (1)	48
SH-15	Ore Dock	Surface	ND (0.16)	**3.1**	2.4	ND (0.068)	ND (0.94)	73
SH-17	Ore Dock	Surface	ND (0.16)	2.9	2.0	ND (0.055)	ND (1)	22

Sampling during the 2008 study further evaluated surface water copper concentrations in Skagway Harbor, including samples at seven stations previously sampled in 2007 as well as at sites along the railroad dock, the ferry dock, and in the small boat harbor. The only water sample collected in 2008 that had detectable levels of dissolved copper was from the reference site, REF-1, with a value of 5.3 µg/L, above the acute and chronic water quality criteria (3.1 and 4.9 µg/L, respectively). This leads to the possibility that elevated levels of metals may be part of the natural condition of the area (Tetra Tech 2009).

In addition, in 2007, dissolved copper samples were not filtered in the field. Rather, raw water was shipped to the lab, where the sample was then filtered and analyzed. However, for the 2008 sampling, the samples were filtered in the field, preserved, and shipped to the lab for analysis. It was noted in 2007 that the high dissolved copper values exceeded the values of the total copper by a reasonably large margin for every sample site. Because copper was undetected at all sample sites in 2008, it is possible that the dissolved copper values reported by the lab in 2007 for Skagway Harbor were an artifact of handling contamination (Tetra Tech 2009). Alternatively, large cruise ships stopped discharging wastewater in Skagway Harbor in 2008 due to a new state permit, which could have resulted in the lower copper levels in 2008.

Other metals concentrations measured during the 2007 and 2008 studies were below ambient water quality criteria. In addition, results of toxicity testing in 2007 indicate no acute toxicity associated in the surface water samples from Skagway Harbor. The 2007 study was conducted during the cruise ship season to evaluate the potential for ship traffic to resuspend metals by disturbing bottom sediments in the harbor. The low surface water metal concentrations suggest that metals are not likely being resuspended due to ship traffic in the harbor. Low suspended solids measured in samples collected in the wake of a cruise ship leaving the harbor further supports this conclusion. In addition, mussels were sampled in 2007 to measure tissue concentration of metals and evaluate the associated ecological risk. The concentrations of metals observed in mussels sampled around the harbor suggest a low risk potential due to water column metals. Available data do not suggest that water column metals are violating applicable water quality standards in Skagway Harbor. With sediment concentrations of metals decreasing over the years, the threat to resuspension of metals to the overlying water column will also decrease. Available water column data support the assumption that metals are not likely the current cause of the impairment in Skagway Harbor.

4.2. Petroleum Hydrocarbon Monitoring

ADEC contracted further sampling in Skagway Harbor in September 2008 with the overall objective to evaluate the levels of petroleum derivatives (i.e., volatile organic compounds [VOC], PAHs, oil and grease, and total petroleum hydrocarbons [TPH]) in sediments and the water column of the harbor to determine whether petroleum products was the cause of the sediment toxicity impairment. As part of the 2008 study, sediments in Pullen Creek were also sampled and analyzed for petroleum hydrocarbons to evaluate potential impairment and to evaluate whether the creek is a source of contaminated sediment to the harbor. Sample design for the 2008 sampling built on the 2007 sampling to further characterize the potential contamination from petroleum products. Table 4-4 provides a summary of the Skagway Harbor and Pullen Creek monitoring locations, media, and sample constituents.

Table 4-4. Skagway Harbor 2008 petroleum hydrocarbon monitoring summary

Location description	Site	Surface water				Sediment	
		VOCs	PAHs	TPH	Oil and gas	PAHs	TPH
Skagway Harbor	SH-4	X	X	X	X	X	X
	SH-7	X	X	X	X	X	X
	SH-9	X	X	X	X	X	X
	SH-10	X	X	X	X	X	X
	SH-14	X	X	X	X	X	X
	SH-17	X	X	X	X	X	X
Nakhu Bay	REF1	X	X	X	X	X	X
	REF2	X	X	X	X	X	X
Pullen Creek	PC-1					X	X
	PC-2					X	X
	PC-5					X	X
	REF-PC					X	X

Skagway Harbor

Because 2007 monitoring observations found oil sheens and odors in sediment samples from the harbor, sediment and surface water samples were collected at six locations (SH-4, SH-7, SH-9, SH-10, SH-14, and SH-17) and analyzed for petroleum derivatives as part of the 2008 monitoring study. Sampling focused near the Ore Dock due to observations made during the chemical and toxicological evaluations in 2007. Surface waters were analyzed for VOCs, PAHs, TPHs, and oil and grease, and surficial sediments (top 2-4 inches) were analyzed for total organic carbon (TOC), PAHs and TPH. TPH was measured as the combination of the diesel and residual range organics fractions. Sediment and surface water samples were also collected at two new reference sites further north in Nakhu Bay than previous locations. There was some uncertainty as to whether the 2007 reference site might be influenced by Skagway Harbor due to tides and currents based on the data showing metals concentrations comparable to those measured in many harbor samples. Figure 4-3 presents the monitoring locations in Skagway Harbor and Figure 4-4 presents the locations of the two reference sites.

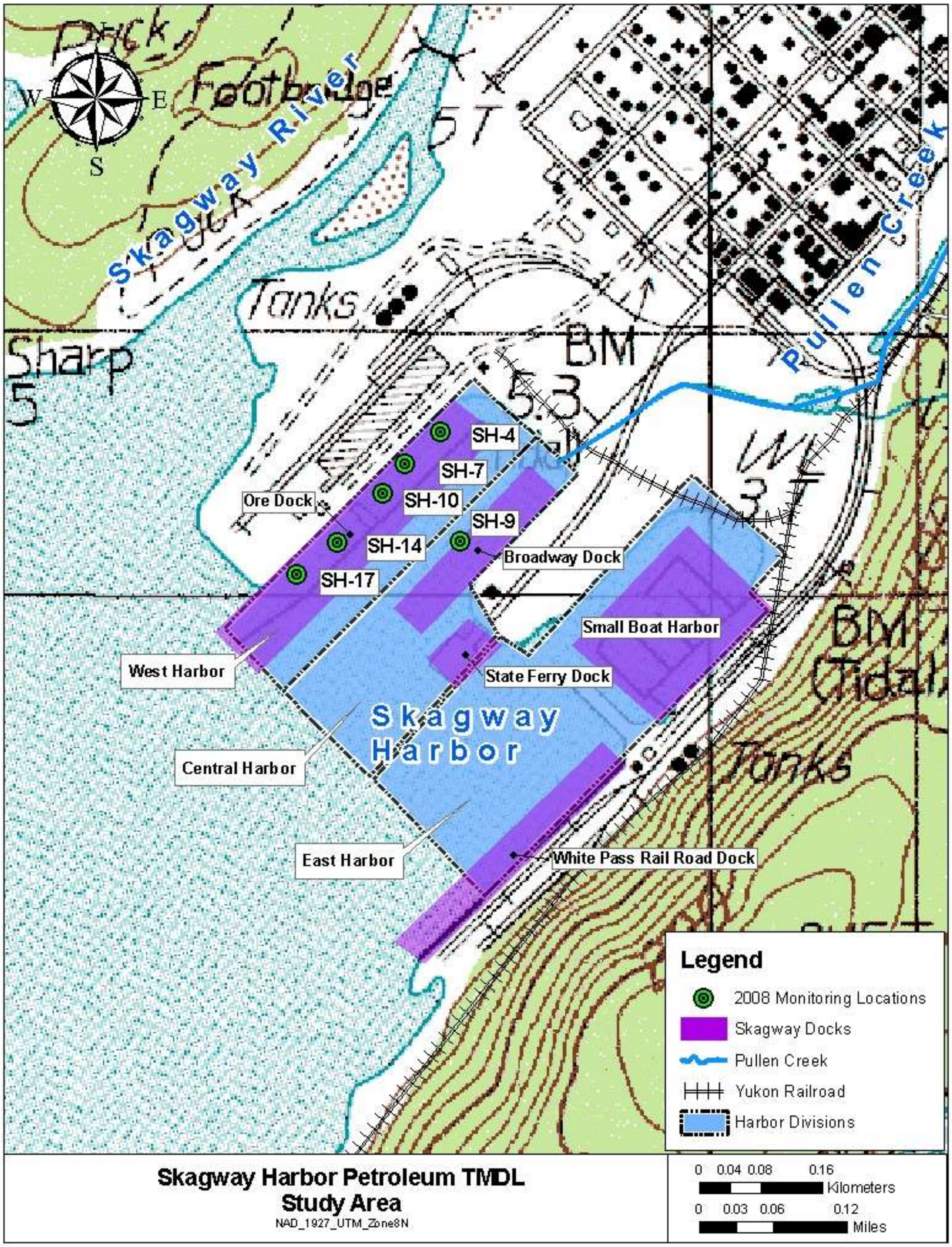

Figure 4-3. Skagway Harbor 2008 sediment monitoring locations

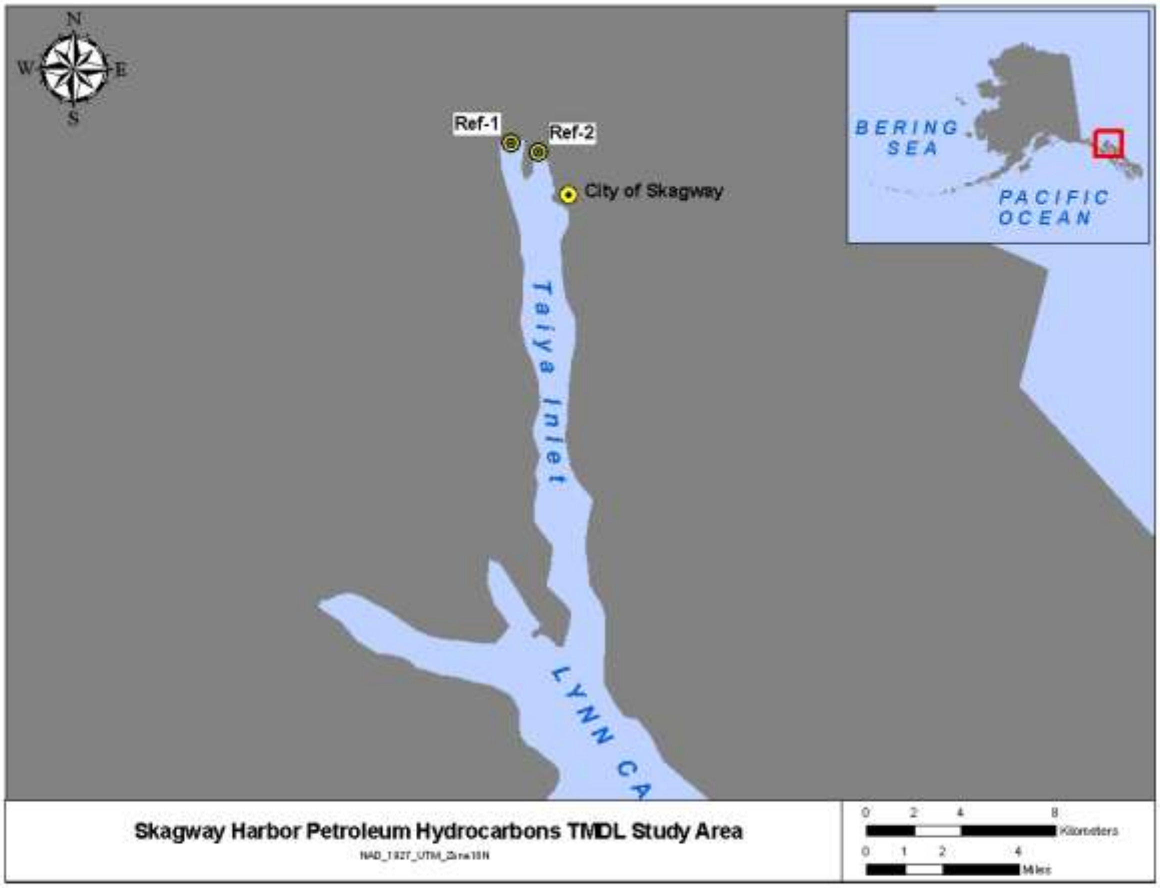

Figure 4-4. Skagway Harbor 2008 reference monitoring locations

Surface Sediment Results

The surficial sediment samples collected from the Skagway Harbor sites were analyzed for various PAHs and TPHs (Table 4-5). The concentrations of PAHs measured in the Skagway Harbor sediments were compared to the available NOAA PEL, TEL, and ERL sediment quality guidelines. PAHs for which sediment screening levels are available include, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, naphthalene, phenanthrene and pyrene. For sites that exceeded the TEL, results in Table 4-5 are bold for sites that exceeded the TEL, bold and underlined for sites that exceeded the ERL, and bold, underlined and highlighted for sites that exceeded the PEL. A summary of the total PAH results is shown in Figure 4-5 and Figure 4-6 presents the total PAH concentrations measured at sediment monitoring sites during the 2008 study in Skagway Harbor.

All PAHs measured in the sediment from Skagway Harbor site SH-17 were either below detection or detected at concentrations lower than the NOAA TEL for sediment. Concentrations of PAHs at both reference sites, REF-1 and REF-2, were all non-detected. All other sites had concentrations that exceeded the NOAA TEL for multiple PAHs analyzed, with sample sites SH-4, SH-7, and SH-10 having concentrations that exceeded the NOAA TEL for all PAHs. In addition, Skagway Harbor sample sites SH-4, SH-7, SH-9, and SH-10 had sediment concentrations of PAHs that exceeded the NOAA PEL for multiple PAHs. No site exceeded the PEL for total PAHs. Sites SH-4, SH-7, SH-9, and SH-10 exceeded the ERL, and SH-14 exceeded only the TEL.

Table 4-5. Skagway Harbor 2008 sediment quality results

Group	Parameter	Units	SH-4	SH-7	SH-9	SH-10	SH-14	SH-17	REF-1	REF-2
PAHs	1-Methylnaphthalene	µg/kg	34	250	16	85	U	U	U	U
	2-Methylnaphthalene	µg/kg	**47**	**390**	**33**	**140**	10	U	U	U
	Acenaphthene	µg/kg	**210**	**1,100**	**97**	**460**	**41**	U	U	U
	Acenaphthylene	µg/kg	**82**	**62**	**27**	U	**17**	U	U	U
	Anthracene	µg/kg	**190**	**290**	**160**	**110**	**59**	U	U	U
	Benzo(a)anthracene	µg/kg	**910**	**670**	**570**	**390**	**380**	17	U	U
	Benzo(a)pyrene	µg/kg	**400**	**290**	**220**	**140**	**120**	U	U	U
	Benzo(b)fluoranthene	µg/kg	980	520	500	240	220	18	U	U
	Benzo(g,h,i)perylene	µg/kg	77	62	38	30	22	U	U	U
	Benzo(k)fluoranthene	µg/kg	540	400	260	190	180	12	U	U
	Chrysene	µg/kg	**1,200**	**730**	**790**	**400**	**340**	23	U	U
	Dibenzo(a,h)anthracene	µg/kg	**50**	**31**	**25**	U	**14**	U	U	U
	Fluoranthene	µg/kg	**3,300**	**3,300**	**1,900**	**1,400**	**810**	50	U	U
	Fluorene	µg/kg	**230**	**820**	**190**	**450**	**42**	U	U	U
	Indeno(1,2,3-cd)pyrene	µg/kg	96	74	46	37	29	U	U	U
	Naphthalene	µg/kg	**42**	**290**	U	**68**	U	U	U	U
	Phenanthrene	µg/kg	**1,000**	**2,400**	**730**	**1,200**	**190**	U	U	U
	Pyrene	µg/kg	**2,100**	**2,100**	**1,300**	**810**	**640**	28	U	U
	Total PAHs	µg/kg	**11,488**	**13,779**	**6,902**	**6,150**	**3,114**	148	U	U
TPH	Residual Range Organics	mg/kg	U	U	U	U	U	U	U	U
	Diesel Range Organics	mg/kg	U	20	U	U	U	U	U	U
TOC	Organic Carbon, Total (TOC)	%	1.6	1.3	0.69	0.66	0.46	0.19	1.9	0.15
TS	Solids, Total	%	55.4	51.4	72.8	53.5	77.7	83.2	67.2	84.4

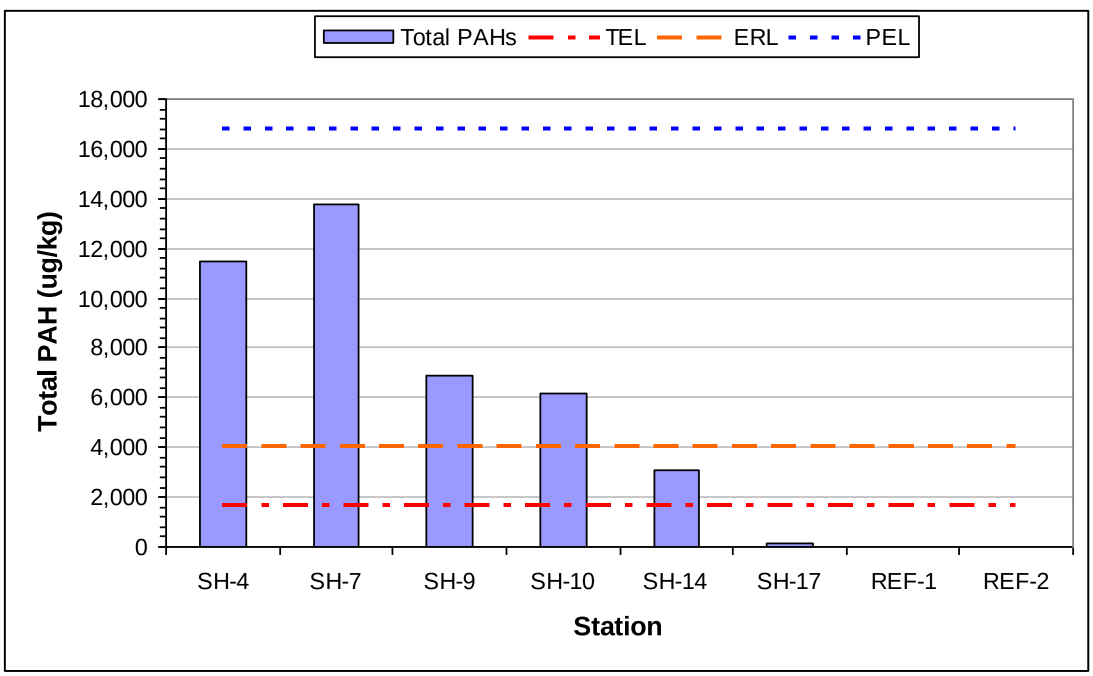

Figure 4-5. Skagway Harbor 2008 total PAHs sediment monitoring results

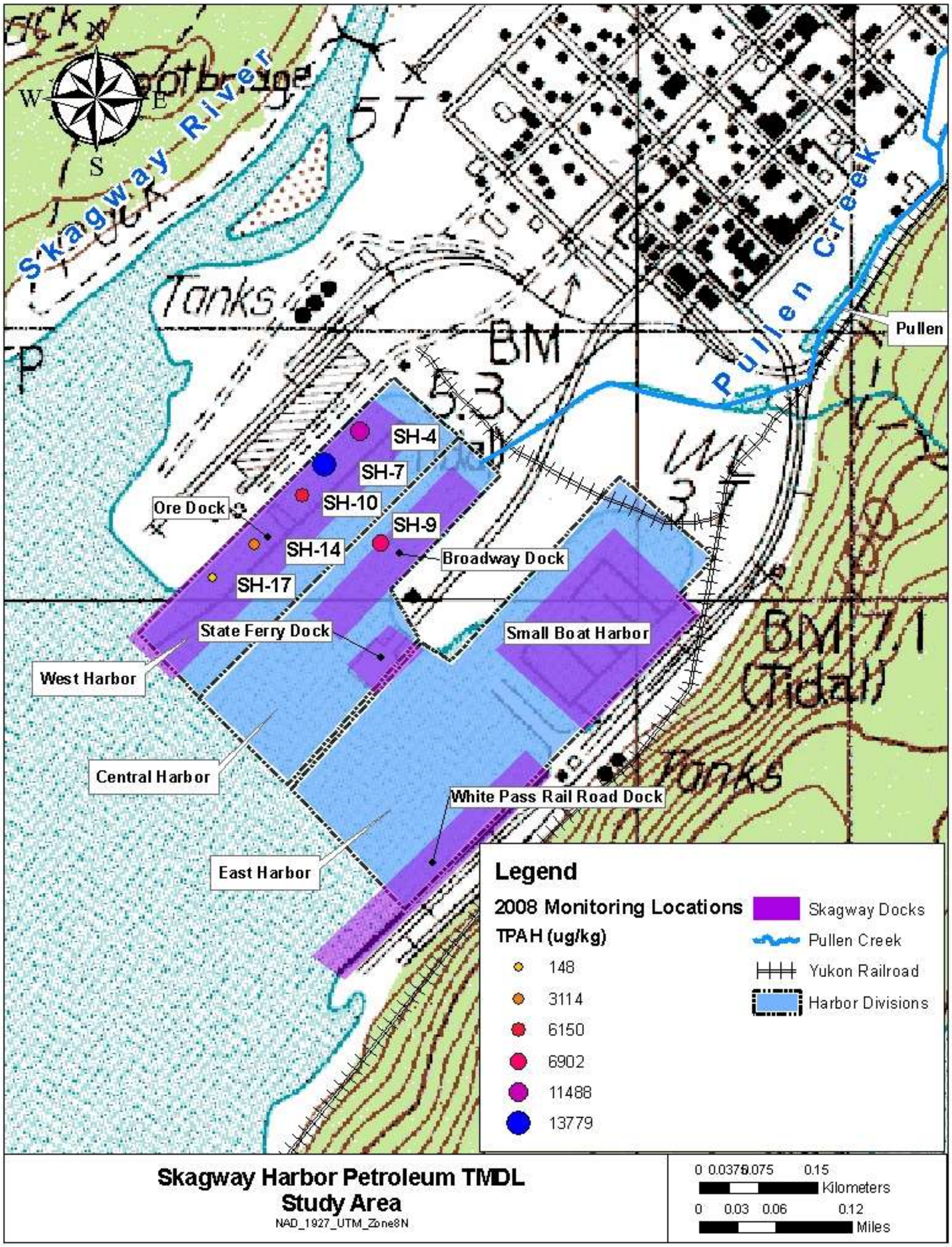

Figure 4-6. Total PAH concentrations in sediment samples collected during the 2008 study in Skagway Harbor

In addition, sites SH-4 and SH-7 had detectable concentrations of all analyzed PAHs, while site SH-9 had detections of all PAHs except Napthalene. Sites SH-10 and SH-14 also detected the majority of PAHs sampled for, with only two constituents below detection levels at each. For PAH's that have screening levels available, benzo(a)anthracene, chrysene, fluoranthene, and pyrene were measured in every Skagway Harbor sediment sample. Chrysene concentrations ranged from 23 (SH-17) to 1,200 (SH-4) μg/kg, flouranthene concentrations ranged from 50 (SH-17) to 3,300 (SH-4 and SH-7) μg/kg, and pyrene concentrations ranged from 28 (SH-17) to 2,100 (SH-4 and SH-7) μg/kg. For all other parameters and measured values, see Table 4-5. Diesel range organics and residual range organics were un-detected at all monitoring locations except SH-7, which had detectable concentrations of diesel range organics (20 mg/kg).

The results of this sampling suggest that levels of PAHs are at concentrations high enough to impair biological communities and is likely the source of toxicity observed in 2007. Based on the results of the 2007 toxicity and chemical analysis and the follow up 2008 sediment chemical analysis, the concentrations of organic compounds observed are more likely to be the current source of biological impairment (Tetra Tech 2009).

During the 2007 study toxicity was observed using sediment and pore water from several sites in Skagway Harbor. The original hypothesis was that the elevated levels of metals present in Skagway Harbor were the source of toxicity, but after various TIE modifications, it was concluded that metals were not the primary toxicant. Observations of a petroleum sheen, blackened sediment, and an odor associated with petroleum substances were associated with sediments and pore waters that yielded significantly higher toxicity then those without those observations. Therefore, petroleum derivatives were hypothesized to be a potential toxicant. The concentrations of petroleum derivatives measured in the 2008 sampling of sediment in Skagway Harbor (sites SH-4, SH-7, SH 9, SH-10 and SH-14) is a more likely source of the toxicity observed in the 2007 Skagway Harbor sediment toxicity testing.

Figure 4-7 shows the results of a linear regression analysis using the 2007 Neanthes arenaceodentata toxicity results compared to the 2008 PAH data. Significant conclusions cannot be made from a linear regression model using only three data points, also the concentrations of PAHs found in 2008 may be slightly different than those present in 2007, however it stands to reason that sample site SH-14 had a 75% survival rate, and also had the lowest concentration of PAHs, while sample sites SH-7 and SH-10 had higher concentrations of PAHs, and both had 0% survival. Similar correlations were not found when comparing the Leptocheirus plumulosus percent survival values from 2007 to the 2008 PAH concentrations. Leptocheirus are amphipods which live on or frequent the sediment surface, while Neanthes are worms which burrow deeper into the sediment. Because Leptocheirus are not in as direct contact with the sediment during toxicity testing as the Neanthes, this could be a possible explanation why a response correlation is only noted with the Neanthes data (Tetra Tech 2009).

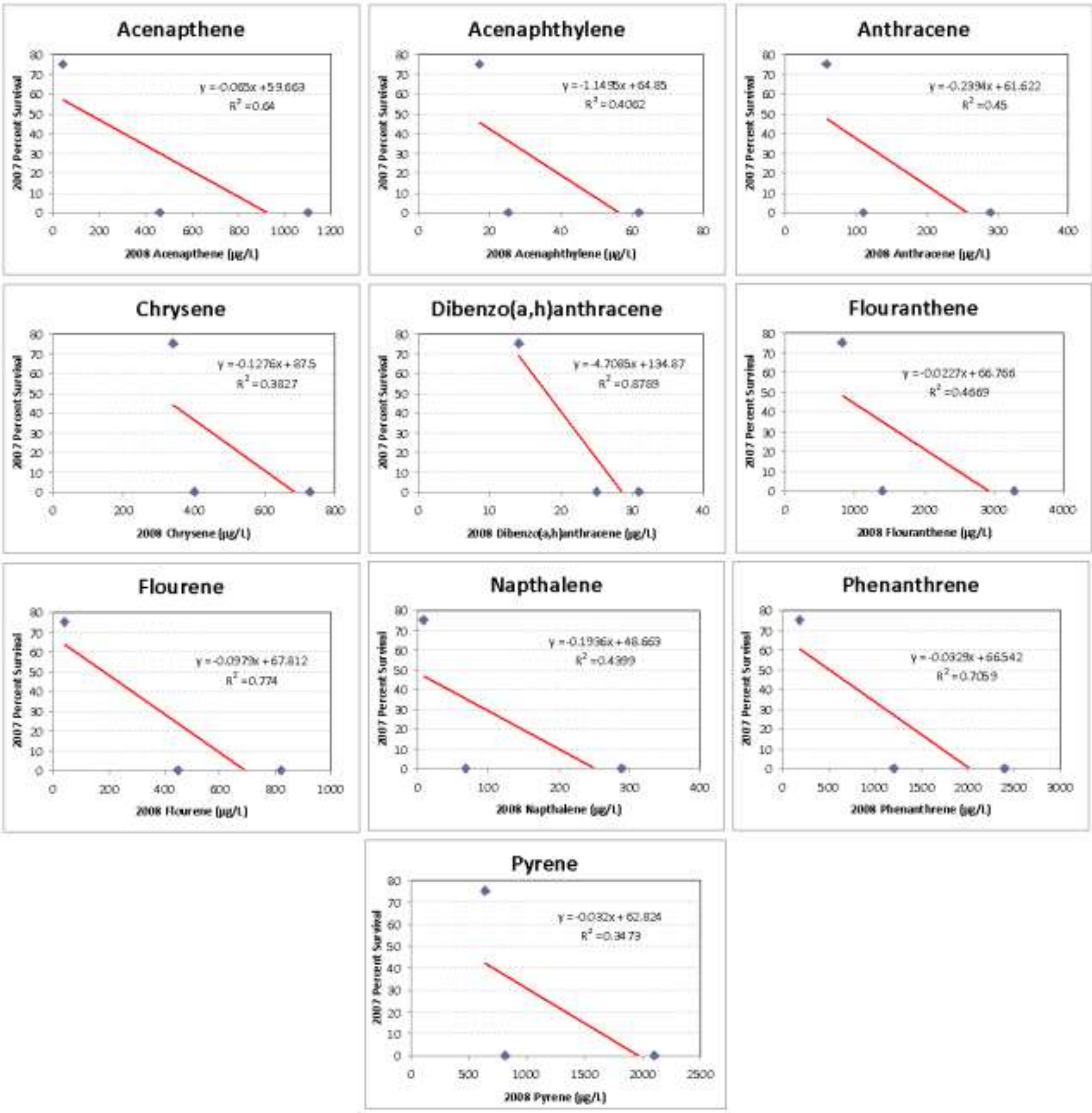

Figure 4-7. Regression analysis of 2007 percent survival rates and 2008 PAH sediment concentrations

Surface Water Results

Petroleum derivatives were undetected at all surface water sample locations in Skagway Harbor and, therefore, well below Alaska's applicable water quality criteria for dissolved TAqH and TAH (15 and 10 µg/L, respectively). In addition, concentrations of TPHs and VOCs, which include TAHs, in the surface water sampled from Skagway Harbor, including both reference sites, were not detected. The lack of petroleum derivatives detected in the surface waters is likely due to their hydrophobic nature. Because high concentrations of petroleum derivatives were found in the sediment of Skagway Harbor, it appears that the sediment acts as a sink for petroleum derivatives under normal conditions. If the sediment is disturbed (from storm conditions, excessive boat traffic, abnormal currents, or dredging), the petroleum derivatives may be re-suspended into the water column but would likely become reassociated with the sediments after a brief period of time (Tetra Tech 2009).

Pullen Creek

Pullen Creek sediments were evaluated at three locations (sites PC-1, PC-2, and PC-5) and at a reference site (PC-REF) to determine if Pullen Creek is a potential source of organics to Skagway Harbor (Figure 4-8). Note that the reference site is not depicted in the figure, but is located on a tributary to the Skagway River approximately 1 mile north of the city of Skagway. The surficial sediment samples collected from the Pullen Creek sites were analyzed for various PAHs and TPHs.

Surface Sediment Results

Sediment samples were collected from Pullen Creek to evaluate their potential as a source of PAHs to Skagway Harbor. Surficial sediment samples collected from three sites on the creek and one reference site were analyzed for various PAHs and TPHs (Table 4-6). The concentrations of PAHs measured in Pullen Creek sediments were compared to the available NOAA PEL and TEL freshwater sediment quality guidelines. (ERL guidelines are not available for freshwater sediments.) PAHs for which sediment screening levels are available include, benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, phenanthrene and pyrene. For sites that exceeded the TEL, results in Table 4-6 are bold, and for sites that exceeded the PEL results are bold and underlined. Figure 4-9 presents a summary of the Pullen Creek PAH monitoring data for which sediment screening levels are available.

Evaluation of Pullen Creek sediments indicate elevated concentrations of PAHs in downstream sediments collected at site PC-1. Concentrations of PAHs were not detected in the sediment at sites PC-2 and PC-REF, while PC-1 had detected concentrations of all PAHs and PC-5 had detections of some PAHs. Concentrations of petroleum derivatives in Pullen Creek sediment were significantly higher at the downstream site, PC-1, than at any other site. PC-1 was the only site where multiple PAHs were measured at concentrations exceeding the freshwater TEL sediment quality guideline. Concentrations of phenanthrene and pyrene also exceeded the PEL sediment quality guideline at PC-1. PC-5 was the only other site where a sample had a concentration exceeding the TEL (phenanthrene). Concentrations of residual range organics were not detected in any Pullen Creek sample. Concentrations of diesel range organics were not detected at sites PC-2 and PC-REF with detection limits of 12 and 15 mg/kg, respectively, but were detected at sites PC-1 and PC-5 with concentrations of 14 and 30 mg/kg, respectively.

Analysis of petroleum derivatives in Pullen Creek observed that the furthest downstream site, PC-1, had the highest measured concentrations. PC-1 PAH concentrations were similar to the PAH concentrations found in Skagway Harbor site SH-14, which represents one of the lesser contaminated harbor sites. The sample site PC-1 is located just upstream of Pullen Pond in a wider, slower moving segment of Pullen Creek. The decrease in stream flow at the sample site may be causing hydrophobic petroleum derivatives passing through Pullen Creek to settle in the sediment at this location. These sediments might act as a sink, trapping the PAHs under normal conditions. Just like in Skagway Harbor, it is thought that the organic compounds are unlikely to be present in the surface waters of Pullen Creek due to their hydrophobic nature. Therefore, Pullen Creek sediments have the potential to be a source of PAHs to Skagway Harbor if the sediments are disturbed.

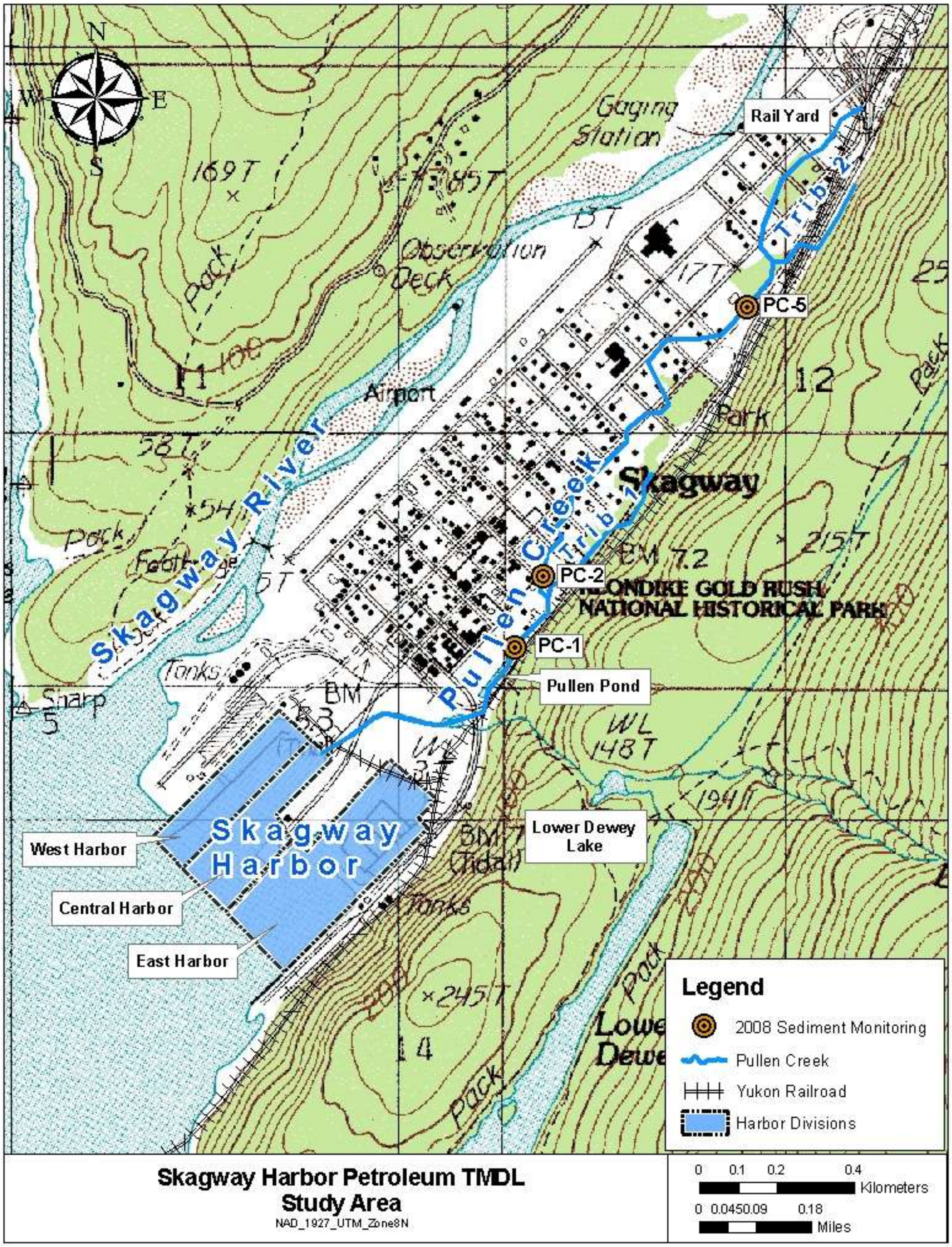

Figure 4-8. Pullen Creek petroleum hydrocarbon monitoring locations

Table 4-6. Pullen Creek 2008 sediment quality results

Group	Parameter	Units	PC-1	PC-2	PC-5	PC-REF	TEL	PEL
PAHs	1-Methylnaphthalene	ug/kg	24	U	110	U		
	2-Methylnaphthalene	ug/kg	27	U	150	U		
	Acenaphthene	ug/kg	67	U	U	U		
	Acenaphthylene	ug/kg	26	U	U	U		
	Anthracene	ug/kg	240	U	U	U		
	Benzo(a)anthracene	ug/kg	**300**	U	20	U	31.7	385
	Benzo(a)pyrene	ug/kg	**240**	U	U	U	31.9	782
	Benzo(b)fluoranthene	ug/kg	250	U	U	U		
	Benzo(g,h,i)perylene	ug/kg	110	U	U	U		
	Benzo(k)fluoranthene	ug/kg	180	U	U	U		
	Chrysene	ug/kg	**300**	U	29	U	57.1	862
	Dibenzo(a,h)anthracene	ug/kg	40	U	U	U		
	Fluoranthene	ug/kg	**680**	U	U	U	111	2,355
	Fluorene	ug/kg	130	U	18	U		
	Indeno(1,2,3-cd)pyrene	ug/kg	91	U	U	U		
	Naphthalene	ug/kg	21	U	98	U		
	Phenanthrene	ug/kg	**690**	U	**94**	U	41.9	515
	Pyrene	ug/kg	**760**	U	48	U	53	875
	Total PAHs	ug/kg	4,176	U	567	U		
TPH	Residual Range Organics	mg/Kg	U	U	U	U		
	Diesel Range Organics	mg/Kg	14	U	30	U		
TOC	Organic Carbon, Total	%	0.66	0.22	2.4	3.1		
TS	Solids, Total	%	77.9	79.5	55.8	65.9		

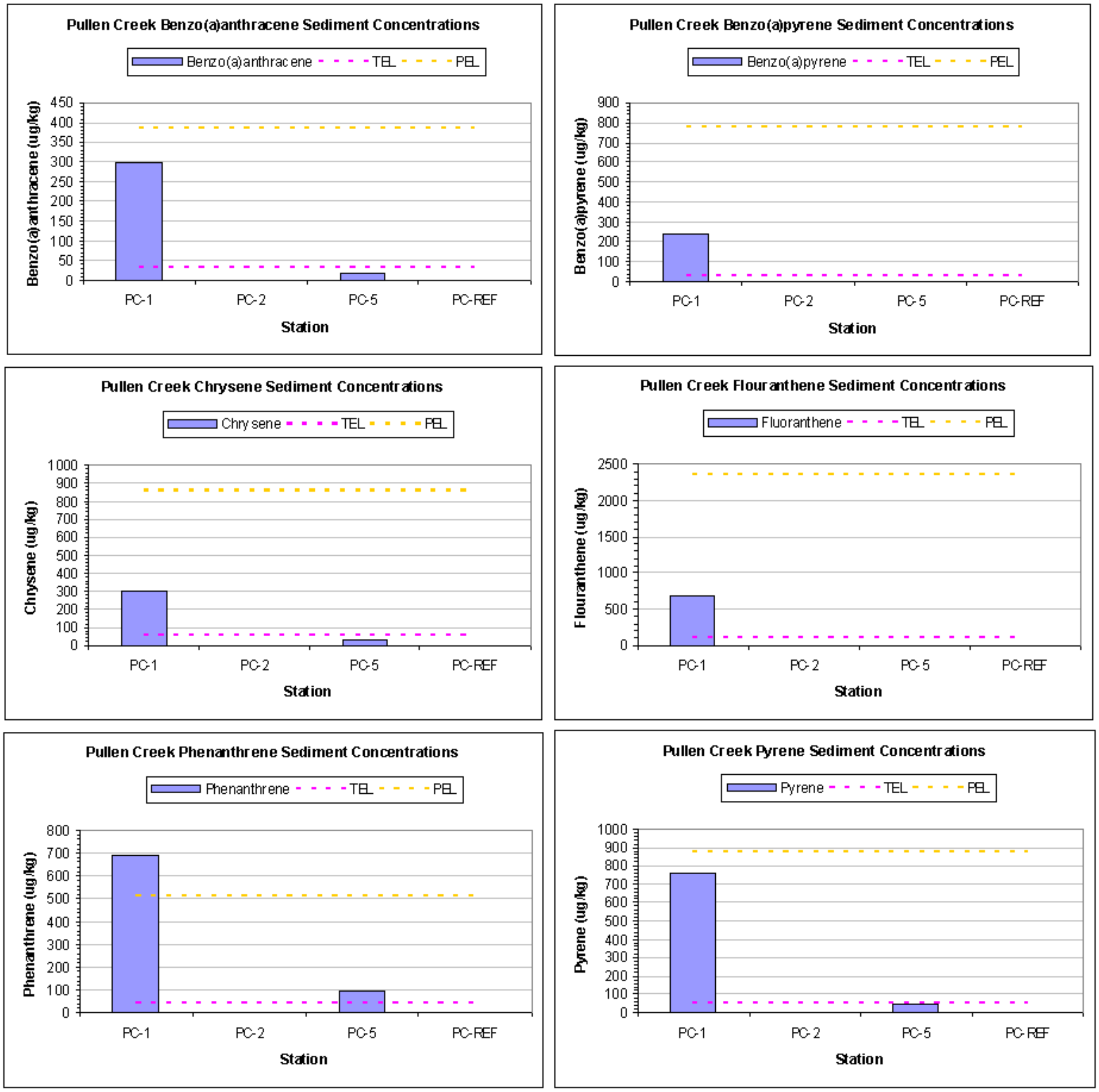

Figure 4-9. Pullen Creek 2008 PAH sediment monitoring results

4.3. Summary

Monitoring conducted in 2007 included toxicity test data, analytical data, and monitoring observations that indicated that metals are no longer the primary source of toxicity present in the Skagway Harbor sediment as has been historically thought. Based on the 2007 monitoring results, ADEC hypothesized that petroleum derivatives were present in Skagway Harbor sediment due to observed sheens and odors in sediment samples (Tetra Tech 2008). A follow up monitoring study conducted in 2008 found that levels of petroleum derivatives in Skagway Harbor sediment were, in most cases, above the NOAA chronic quality guideline (TEL) and the ERL guideline. In addition, some petroleum derivatives found in Skagway Harbor sediment exceeded the NOAA acute quality guideline (PEL). However, petroleum derivatives were not detected in the water column in Skagway Harbor. It appears that the sediment in

Skagway Harbor is a sink for petroleum derivatives, which do not enter the water column under normal conditions due to their hydrophobic nature. In general, however, the high concentrations of petroleum derivatives found in the Skagway Harbor sediment are likely the cause of the sediment toxicity observed in 2007 and pose a threat to native biota.

The 2007/2008 data from the west harbor and central harbor sites show that both of these areas meet applicable water column concentration criteria, but have sediment petroleum hydrocarbon concentrations exceeding the NOAA ERL screening level for Total PAHs (4,022 µg/L).

Monitoring of petroleum hydrocarbons in Pullen Creek sediments found elevated levels in the lower reaches (PC-1) of the creek. The lower site, PC-1, is located directly above Pullen Pond and is on a slower, wider segment of the creek. It is thought that due to the hydrology of the lower reach, it might be acting as a sink for petroleum contaminants attached to suspended sediments. Therefore, Pullen Creek's potential as a source of petroleum hydrocarbons to the harbor is, likely, greatest when sediments are disturbed during storm events (see Section 5).

5. Potential Sources of Petroleum

Based on analysis of the 2008 monitoring data, it is believed that the current sediment toxicity impairments in Skagway Harbor are primarily the result of petroleum contamination. Possible sources of petroleum contamination to the harbor include:

- On-shore contaminated sites
- Historic and recent surface water spills
- Pullen Creek
- Stormwater runoff
- Upland nonpoint sources
- NPDES/APDES facilities
- Harbor and vessel activities (petroleum storage and transfer facilities, and docks and harbors)

The following subsections summarize the information that is available about these potential sources of petroleum. Because of the persistence of PAHs in the environment, it is possible that past spills, historical activities, or contaminated sites could have contributed to the elevated PAH levels in harbor sediments. Available information does not indicate the existence of an active source of petroleum; however, the following descriptions describe potential sources, both from past or current activities. While sources described in this section are possible contributors to the petroleum impairment in Skagway Harbor, data are not available to quantify their petroleum inputs or establish a direct link between their inputs and impairment. Therefore, the TMDL does not calculate individual allocations for these sources. Instead, ADEC will use the information on sources and their possible contribution to impairment to identify and target future monitoring and management strategies to reduce petroleum inputs and restore water quality standards.

5.1. Contaminated Sites

The City of Skagway has several contaminated sites that are impacted with petroleum-related pollutants. ADEC's Division of Spill Prevention and Response, Contaminated Sites Program is responsible for managing clean-up operations at contaminated sites in the state. This program uses two databases to track contaminated sites: Contaminated Sites (CS) and Leaking Underground Storage Tanks (LUST). A review of the CS and LUST databases identified 10 contaminated sites in the "City of Skagway" search area that were characterized as open cases, meaning cleanup has not been completed at the site. The sites range from residences where fuels were improperly disposed to bulk fuel farms with releases of up to a half-million gallons of petroleum fuels. Table 5-1 presents descriptions of these sites.

Table 5-1. Petroleum contaminated sites in the City of Skagway

Site name	Location	File ID	Problem description
Petro Marine Skagway Truck Rack	10 Beach Road near Skagway, AK 99840	1526.38.001	15 cubic yards of impacted surface soil recovered at 265-gallon diesel spill. Later, in preparation for pouring concrete, additional soil was excavated. Volume now totals about 175 cubic yards stockpiled on-site. Transfer from PERP.
White Pass 6-Mile Spill	6 Miles North of Skagway, Skagway, AK 99840	1526.38.010	Spill of unknown quantity of arctic diesel on 10/94 caused by heavy equipment rupturing pipeline adjacent to railroad.

Site name	Location	File ID	Problem description
Skagway Diesel Spill Well #2	15th & Alaska Streets, Skagway, AK 99840	1526.38.008	On a cold night in January, children out playing accidentally bumped into the line leading from the tank to the generator in well house #2 and caused the line, brittle in the near zero temperatures, to break. The release was estimated at 300 gallons of diesel fuel. Spill posed potential risk to the municipal water supply.
Skagway Wharf Tanks Area	Skagway Boat Harbor, Skagway, AK 99840	1526.38.009	Petroleum contamination from 11 tanks historically located in this area. At least one catastrophic (0.5 million gallon) gasoline release is known to have occurred in the 1970s. This site was operated by the military at one time and has been purchased by White Pass.
Skagway State Street Mystery	20th and State Streets, Skagway, AK 99840	1526.38.007	Free product (diesel) was encountered in 11/98 at the vacant lot at 20th and State Streets. Product appeared to be flowing onto the property from the DOT right-of-way. Elevation ~23'.
White Pass Coach Cleaning Shop	21st and State Streets, Skagway, AK 99840	1526.38.002	Removal of TPH contaminated soils occurred September 2000. DRO up to 8000ppm left underneath sidewalk. Potential Institutional Control site due to contamination left beneath the sidewalk.
Alaska Liquor Store HOT	290 2nd Avenue, Skagway, AK 99840	1526.38.014	Due to a line failure, up to 250 gallons of diesel were released from an aboveground heating oil tank into the crawlspace beneath the building. No free product was observed under the building. The proposed cleanup includes installation of a vapor barrier and in situ remediation. The City of Skagway is served by a municipal water system, although some individual wells are present. The three municipal drinking water supply wells are located on 15th Avenue and Main Street and 15th Avenue and Alaska Street, approximately 0.4 mile north of the source area, and the well depths are 75', 80', and 120' below ground surface. Source area is approximately 0.1 mile west northwest of Pullen Pond and approximately 0.1 mile west of Pullen Creek. A fish hatchery is approximately 0.2 mile northeast of the source area.
Chevron - Hoovers	444 4th Avenue; , Skagway, AK 99840	1526.26.003	After underground storage tank (UST) closure by removal in 1993, petroleum release investigation found that two residual subsurface soil samples collected beneath the former dispenser island had concentrations of gasoline hydrocarbons of 22,000 mg/kg and benzene concentration of 49 mg/kg. One of two soil samples under the diesel UST had a diesel hydrocarbon concentration of 590 mg/kg. Five other soil samples in the UST excavation met applicable cleanup levels and the volume of contaminated material shipped off-site for remediation was 25 cubic yards. Groundwater was not encountered and was not investigated; depth is estimated at ten feet below ground surface. The ground water and indoor air vapor intrusion exposure pathways to residual soil contamination are complete. If petroleum contamination reached ground water it could have migrated off-site and may present an exposure risk to private water wells, if present, in the area of 4th and Main Street in Skagway. The facility currently operates as a restaurant; soil vapors from residual gasoline contamination could pose an exposure risk to the occupants.
Services Unlimited	State & Second Streets, Skagway, AK 99840	1526.26.005	Fuel contaminated soils encountered during UST closure. Approx 150 cubic yards of fuel affected soil excavated and stockpiled.

Site name	Location	File ID	Problem description
Residence - 475B 7th Avenue	475B 7th Avenue, Skagway, AK 99840	1526.38.015	On 9/6/07, the owner of a residential rental property removed heating fuel from an aboveground home heating oil tank, placed it in trash cans, and did not cover the cans with lids. Rain water displaced the fuel and it was released to the ground. The contamination may be impacting an adjacent property.

5.2. Surface Water Spills

Petroleum fuel spills have occurred occasionally in the study area. Because development in the area is concentrated near shorelines and sea-based industry is an important component of the local economy, spills and releases often occur near or on the water. ADEC's Division of Spill Prevention and Response tracks reports of chemical spills through its Prevention and Emergency Response Program. A query of the spills database (maintained since 1995) identified the frequency and distribution of petroleum spills in the study area.

Of the six entries dating from October 30, 1998 to June 2, 2009, only one was identified as potentially relevant to the petroleum impairments in the study area. The spill released approximately 400 gallons of petroleum-related products at the City of Skagway waterfront. The cause of the spill was a malfunctioning oil-water separator that was being operated by the White Pass and Yukon Railroad company. Because records for spills occurring prior to July 1995 might not be accurate or complete, it is possible that additional undocumented historical spills have contributed petroleum products to the sediments of Skagway Harbor. The Contaminated Sites database notes that at least one catastrophic (0.5 million gallon) gasoline release is know to have occurred in the 1970's in the vicinity of the West Harbor.

5.3. Pullen Creek

The only drainage feeding directly into Skagway Harbor is Pullen Creek. The entire length (1.5 miles) of Pullen Creek runs along and over the southern boundary of the City of Skagway. Its headwaters begin in the rail yard at the northeast end of town and confluence with Skagway Harbor adjacent to Broadway Dock. As part of the 2008 monitoring study, petroleum derivatives were sampled in Pullen Creek at three locations (PC-1, PC-2, and PC-5; Figure 4-8). Sample site PC-1 was the only location for which PAH concentrations exceeded available freshwater screening levels for multiple compounds (See Section 4.2). Multiple PAHs exceeded the NOAA TEL threshold and Phenanthrene and Pyrene exceeded the PEL threshold at this site. When compared to PAH concentrations observed in Skagway Harbor, PC-1 is similar to site SH-14, which represents one of least contaminated harbor sites.

The stream dynamics of Pullen Creek at PC-1 are different from those at the sites further upstream. Sample site PC-1 is a slower moving, almost pool-like segment of stream which may allow petroleum derivatives to settle out into the sediment. Petroleum derivatives were not analyzed in the water samples from Pullen Creek, however with high levels found at site PC-1, Pullen Creek may be a potential source of petroleum derivatives to Skagway Harbor. Petroleum derivatives that do not settle out at site PC-1, may make their way into Skagway Harbor, and settle into the sediment there. In addition, if a storm event mobilizes sediments in the lower portion of the creek, the associated petroleum derivatives would also be transported to the harbor (Tetra Tech 2009).

5.4. Regulated Stormwater Runoff

EPA's NPDES Stormwater Program regulates stormwater discharges from municipal separate storm sewer systems (MS4s), construction activities, and industrial activities. The City of Skagway is not an

MS4 community requiring coverage under the stormwater program. However, individual construction and industrial facilities in the area could be covered under the Construction General Permit (CGP) or Multi-Sector General Permit (MSGP) for stormwater. To identify facilities covered under the general permits, EPA maintains the Electronic Notice of Intent (e-NOI) database for construction sites and industrial facilities that have applied for coverage under EPA's CGP or MSGP. A review of e-NOI identified an active construction permit discharging to Pullen Creek, an expired industrial permit discharging to Skagway Harbor (AKR05A678), and two active no exposure permits discharging to Skagway Harbor (Table 5-2).

Stormwater from construction facilities are short-term, temporary discharges and are assumed to be an unlikely source of petroleum. In addition, sites covered under the *NPDES General Permit for Stormwater Discharges from Construction Activities* are required to implement control measures to "prevent litter, construction debris, and construction chemicals (e.g., diesel fuel, hydraulic fluids, and other petroleum products) that could be exposed to stormwater from becoming a pollutant source in stormwater discharges." Any future industrial stormwater dischargers would be required to meet the minimum measures and requirements of the stormwater permit. This would include implementing pollution prevention practices to prevent the spill or release of petroleum-related products and to effectively respond to such spills/releases to prevent exposure to stormwater and delivery to receiving waterbodies. Until May 26,2009, stormwater discharges from the Skagway Airport's were covered under the MSGP through industrial permit AKR05A678.

Active no exposure permits AKNOECB41 and AKRNOECD59 are assigned to the Skagway Ferry Terminal and Skagway Airport, both of which have impervious surfaces likely to be contaminated with petroleum derivatives. However, these facilities' conditions of no exposure certify that all industrial materials and activities are protected by a storm resistant shelter to prevent exposure to rain, snow, snowmelt, and/or runoff, therefore preventing the runoff and discharge of pollutants in stormwater.

Table 5-2. Study area facilities operating under general stormwater permits

Tracking Number	Application Type	Project/Site Name	Project City	Status	Receiving Water	Area (acre)
AKR10C586	Construction	E. A. and Jenny Rasmuson Community Health Center	Skagway	Active	Pullen Creek	
AKNOECB41	No Exposure	Skagway Ferry Terminal	Skagway	Active	Skagway Harbor	0.5
AKNOECD59	No Exposure	Skagway Airport	Skagway	Active	Skagway Harbor	78

5.5. Upland Nonpoint Sources

No data or information are available to characterize the potential of runoff from the surrounding watershed to deliver petroleum products to Skagway Harbor. However, watershed runoff, particularly from developed areas surrounding the harbor, is a potential source.

5.6. NPDES/APDES Facilities

The only NPDES- or APDES-permitted facility identified as discharging to Skagway Harbor or its tributary is the City of Skagway Wastewater Treatment Plant (Permit Number AK-002001-0). The discharge outfall is located toward the outer edge of the central harbor, as shown in Figure 5-1. Because petroleum is not typically a pollutant of concern for a domestic wastewater system, the plant's permit does not include numeric effluent limits or monitoring requirements for petroleum products. The permit does include a narrative effluent limitation that states "There shall be no discharge of floating solids, visible foam, or oily wastes which produce a sheen on the surface of the receiving water." Therefore, it is assumed that the plant's discharge does not contain petroleum-related products that would affect the impaired areas or contribute to the impairments in the west and central harbor.

5.7. Harbor and Vessel Activity

The City of Skagway is both a tourist center and an important trade route for Southeast Alaska. It is one of three Southeast Alaskan communities that are connected to the road system allowing access to the lower 48 states, Whitehorse, the Yukon, northern British Columbia, and the Alaska Highway. This makes Skagway an important port-of-call for the Alaska Marine Highway, serving as the northern terminus of the important and heavily-used Lynn Canal corridor (Skagway Traditional Council 2005).

The City is also a popular tourist destination and, thus, a popular port of call for cruise ships. The population of the City doubles in the summer tourist season to support the more than 900,000 visitors. Its strategic position makes Skagway Harbor a busy port and it currently hosts freight barges, ferries, cruise ships, water taxis, and fishing boats (Skagway Traditional Council 2005).

The marine-based economy of the area is served by five docks—the Ore Dock, Broadway Dock, the adjacent State Ferry Dock, the White Pass Rail Road Dock, and the Small Boat Harbor. All of these facilities have the potential to contribute petroleum pollutants to surface waters through their operations including boat discharges of oily bilge water, fueling, and fuel transfers. Figure 5-1 shows the locations of the facilities.

The City of Skagway manages the Small Boat Harbor and the east portion of the Ferry Dock. The west portion of the Ferry Dock is managed by the Alaska Marine Highway and is currently operated by Petro Marine, Skagway. The west end of the Ferry Dock serves as the primary distributor of fuels to charter vessels, commercial boat traffic, Alaska state ferries, and fuel tank trucks that operate in the area. The Ore Dock, Broadway Dock, and the White Pass Rail Road Dock are all managed privately by Pacific and Arctic Railway and Navigation Company dba White Pass & Yukon Route Railroad (PARNCWPYRR).

The docks directly managed by the City of Skagway (Small Boat Harbor and east of the Ferry Dock) currently do not operate under a BMP plan because no fueling services are provided at these docks. Petro Marine currently has in place either Facility Response Plans (FRPs), Spill Prevention, Control and Countermeasure (SPCC) plans, or other contingency plans based on the nature of operations at its facility. It is not currently known what type of management plans are in place at PARNCWPYRR operated docks to reduce the risk of petroleum spills and to mitigate those that do happen.

With limited information about management conditions, it is difficult to assess the risk posed by dock facilities in Skagway Harbor. This degree of difficulty also stems from the requirement of individual responsibility to comply with BMPs and other controls. A large number of commercial and private vessels frequent the study area on a year-round basis and require services at the various docks. Vessels often keep fuel oil on deck in drums or other small containers and operate portable equipment with external tanks, which create the potential for spills if not properly stored. The release of oily bilge water also is a threat because boats moored at a facility for a long period will accumulate excessive water in their bilges. Many bilges are pumped automatically based on water level, and if the bilges are not properly inspected and maintained by owners and operators, these discharges can contain oily mixtures. Additional vessel-oriented sources may include leakages from stern tubes, stabilizers, and thrusters, and below-water exhaust systems.

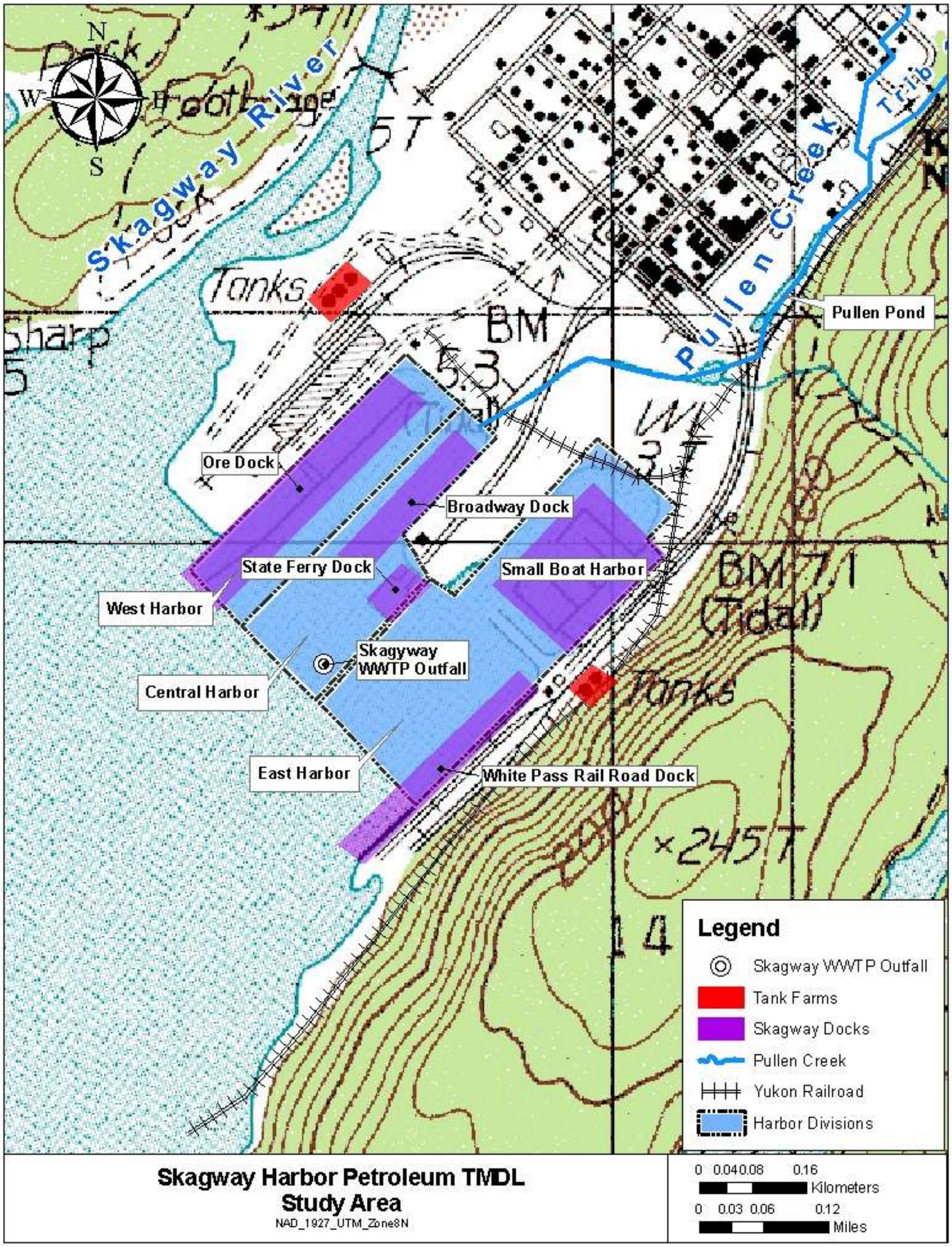

Figure 5-1. Docks and harbors in the Skagway Harbor study area

Between 1942 and 1944 the CANOL #2 pipeline was installed between Skagway and Whitehorse, Canada. This pipeline was designed to carry crude oil from the United States to U.S. military bases along the Alaska Highway. The pipeline was operated by the U.S. Army and the Standard Oil Company until 1962 when it was purchased by White Pass. Transfer of bulk fuel was shifted to rail car and the flow of the pipeline was reversed to support rail operations by the Pacific and Arctic Railway and Navigation Company. The pipeline was removed from service in 1994 with full decommissioning taking place in 1998. The majority of pipeline ran underground from the pump station in the vicinity of the railroad shops to the Skagway Tank Farm. A 12-in. nominal diameter feeder pipeline ran from the pump station at the Skagway Tank Farm to the wharf. Refined fuels including leaded gasoline, diesel fuel, heating oil, and aviation fuel were transported (Golder 1999). The total extent of releases attributed to historic pipeline operations is unknown although available information from Standard Oil and White Pass suggest that several spills were located along the feeder pipeline.

Two tank farms are also located adjacent to docks in the harbor: one at the Ore Dock (Petro Marine Bulk Fuel Plant) and one at the White Pass Rail Road Dock (Figure 5-1). The Petro plant has a 4.6 million gallon storage capacity and distributes fuels at a rate of 450 gallons per minute (personal communication, T. Cochran, January 6, 2010). The facility has a wide range of fuels such as aviation, automotive, heating, and marine diesels available year round. The plant also carries a complete line of lubricants, additives, sorbents, and oil spill response products. This facility is the main distribution outlet for bulk fuels transferred to the Yukon Territory. At the White Pass dock 11 storage tanks are located at the rear of Skagway Terminal Co. Wharf with a total capacity of 63,000 barrels. These bulk fuel storage and transfer facilities have the potential to contribute to the petroleum hydrocarbon impairments in Skagway Harbor.

In addition to the spills or discharges of petroleum products related to activities at docks, another potential source of PAHs from docks is the physical structures themselves. Creosote-treated wood pilings can represent a source of PAHs to surrounding sediments as creosote compounds leach from the wood. NOAA conducted a recent literature review of studies on the hazards to aquatic organisms from treated wood and the factors that affect the leaching of creosote from treated wood into aquatic environments (Stratus 2006). The study concluded that the observed and modeled PAH leaching rates from treated wood and the resulting environmental concentrations and risk vary greatly depending on site-specific conditions, including water temperature, salinity and flow rate and wood type and treatment method. However, the review concludes that rate of leaching of PAHs is generally greater:

- In freshwater than in seawater
- At high temperatures than at low temperatures
- At high flow rates than at low flow rates
- From less dense wood than from denser wood
- From freshly treated wood than from wood that has either been stored after treatment or exposed to water

Data available for Skagway Harbor from the 2008 monitoring events indicate that those individual PAHs that exhibit high concentrations and exceedances of TELs, particularly near the docks, include fluoranthene, pyrene, and Benzo(b)fluoranthene, all of which are considered “heavier” or denser PAHs. However, creosote is characterized primarily by lighter PAHs such as naphthalene, phenanthrene, and anthracene. In general, these PAHs were measured at lower concentrations throughout the harbor. The individual PAHs measured in the harbor (e.g., fluoranthene and pyrene) are more indicative of the effects of oils.

Based on the available source data, activities at docks and harbors likely pose the highest risk to impact water and sediment quality from the release of petroleum pollutants. The 2008 monitoring focused on areas in the vicinity of the docks and harbors because observations of sheens and odors in sediments made during the 2007 monitoring study indicated these areas were the most impacted. The TMDL implementation recommendations focus on these impacted areas

6. TMDL Allocation Analysis

A TMDL represents the total amount of a pollutant that can be assimilated by a receiving water while still achieving water quality standards. A TMDL is composed of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background loads. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation

$$\text{TMDL} = \Sigma\ \text{WLAs} + \Sigma\ \text{LAs} + \text{MOS}$$[3]

The analytical approach used to estimate the loading capacity, existing loads, and allocations for Skagway Harbor are based on the best available information to represent the impairment and expected sources.

6.1. Loading Capacity

The loading capacity for a given pollutant is the greatest amount of pollutant that a waterbody can receive without violating applicable water quality standards, as reflected by the water quality target. If the target is a numeric water quality criterion and discharge sources are present, the loading capacity can be calculated as the highest pollutant load that will not cause the criterion to be exceeded.

Sediment toxicity is the result of petroleum impairments, expected to be caused by elevated concentrations of petroleum hydrocarbons in harbor sediments. Surface water quality currently meets applicable water quality criteria for petroleum hydrocarbons. Because the contamination is the result of concentrations in sediment and possibly the result of past spills, the calculation of loading capacity focuses on existing sediment quality and the reductions necessary to meet the sediment quality TMDL target discussed in Section 3.

The TMDL for Skagway Harbor sediments is concentration-based (µg/kg), consistent with both Alaska's narrative water quality criterion (18 AAC 70.020) and the sediment quality numeric targets established for this TMDL. The loading capacity for petroleum hydrocarbons in Skagway Harbor is equal to the numeric target of 4,022 µg/kg total PAHs, identified in Section 3.4. The following formula was applied to calculate the percent reductions required to meet the LC:

$$\text{Percent Reduction} = \frac{(\text{Maximum Measured Concentration} - \text{TMDL Target})}{(\text{Maximum Measured Concentration})} \times 100$$

Percent reductions were calculated for the West Harbor and Central Harbor portions of Skagway Harbor shown in Figure 6-1. The necessary reductions were calculated based on the sediment total PAHs concentration observed in each area during the 2008 study and the loading capacity of 4,022 µg/kg total PAHs.

[3] When TMDL allocations are expressed as loads, the loading capacity is divided into allocations to individual sources (and margin of safety, if explicit); therefore, the sum of the allocations is equal to the loading capacity. However, when a TMDL is expressed as a concentration or other measure, this equation might not apply. If expressed as concentrations, the allocations are typically equal to a concentration target that represents the loading capacity; therefore all allocations are equivalent to, rather than a portion of, the loading capacity.

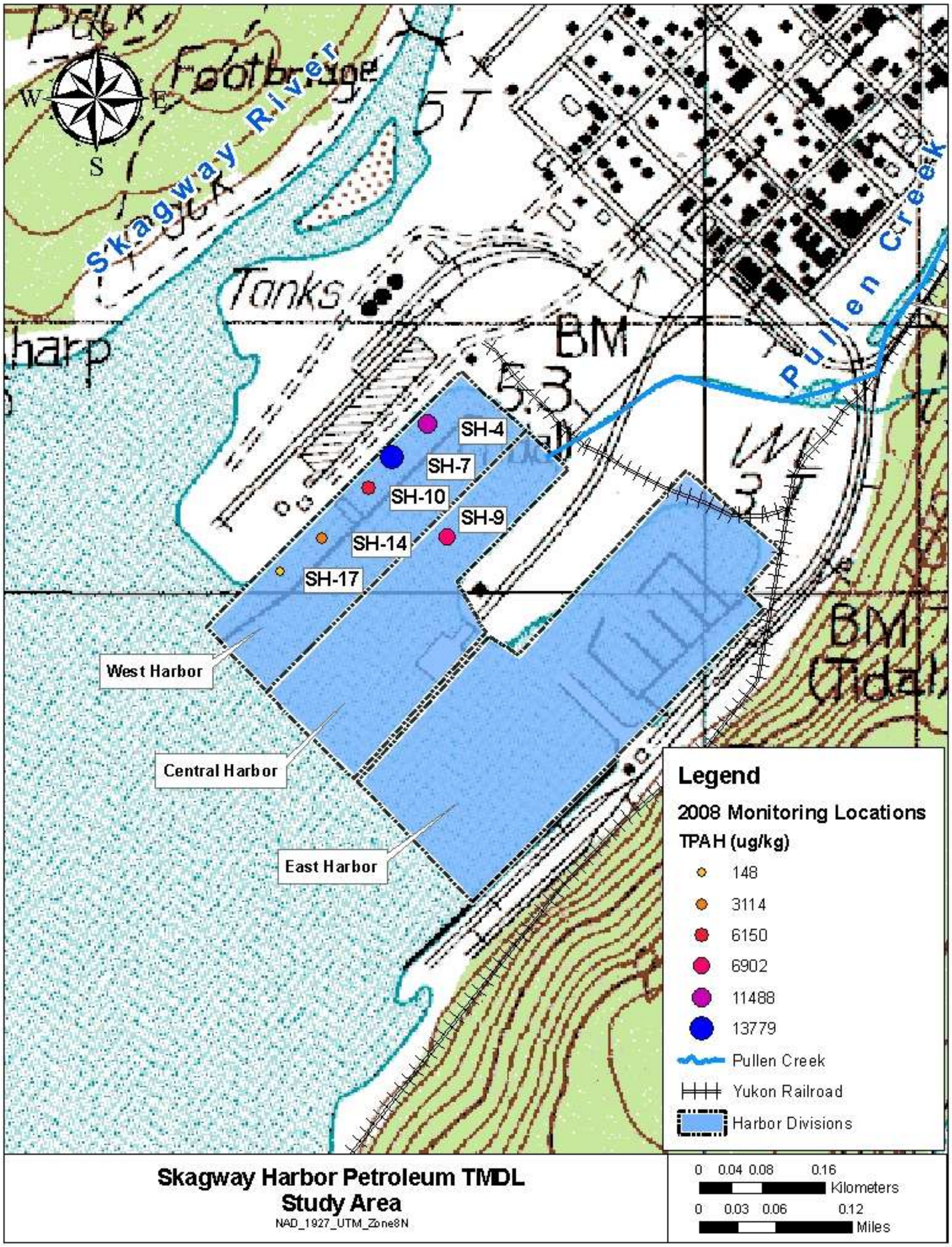

Figure 6-1. TMDL allocation areas and associated sampling sites—Skagway Harbor

6.2. Wasteload Allocation

There are currently no known active permitted discharges of petroleum hydrocarbons to Skagway Harbor. Therefore, the WLAs for these TMDLs are not applicable, as summarized in Table 6-1. If future activity is proposed that will entail discharge of petroleum hydrocarbons to Skagway Harbor that will impact the sediments, the TMDL may be revised to include modified WLAs. Possible revision of the WLA in this TMDL will depend on analysis of relevant factors at that time.

6.3. Load Allocation

The impairment conditions in Skagway Harbor are the result of concentrations of petroleum hydrocarbons embedded in the marine sediments. There are no confirmed existing nonpoint sources of petroleum hydrocarbons affecting the impaired areas other than existing PAH concentrations in the sediments.

The load allocation for petroleum hydrocarbons in Skagway Harbor is equal to the loading capacity, minus the margin of safety. The load allocation is summarized in Table 6-1. Because data are not available to calculate the contribution of individual sources to impairment or establish a predictive link between the various inputs and the resulting sediment concentration, the load allocation can be considered a gross allocation to all sources.

Table 6-1. TMDL load allocations for Skagway Harbor

	Total PAHs (µg/kg)					
Location	Loading Capacity	WLA	LA	MOS	Maximum Observed	Percent Reduction
West Harbor (Ore Dock)	4,022	N/A	3,620	402	13,779	71%
Central Harbor (Broadway/Ferry Dock)	4,022	N/A	3,620	402	6,902	42%

6.4. Margin of Safety

A margin of safety must be included in a TMDL to account for any uncertainty or lack of knowledge regarding the pollutant loads and the response of the receiving water. The margin of safety can be implicit (incorporated into the TMDL analysis through conservative assumptions) or explicit (expressed in the TMDL as a portion of the loadings) or a combination of both. As shown in Table 6-1, the margin of safety for the TMDLs is explicit as 10 percent of the loading capacity reserved to account for uncertainties in the TMDL.

6.5. Seasonal Variation and Critical Conditions

TMDLs must be developed with consideration of seasonal variation and critical conditions. Seasonal variation and critical conditions associated with pollutant loadings, waterbody response, and impairment conditions can affect the development and expression of a TMDL. A TMDL should include WLAs and LAs that ensure the waterbody will maintain water quality standards under all expected conditions and for all seasons.

The impairment in Skagway Harbor is not thought to be associated with a particular season or environmental condition. The impairment is likely a result of historical contamination from occasional oil spills and the day-to-day heavy boat traffic. Therefore, development of the TMDL for specific seasons and conditions is not necessary.

The TMDL loading capacity is based on the target ERL for total PAHs in sediment. ERLs define chemical sediment concentrations at which toxic effects may begin to be observed in sensitive species and are considered protective during all climatic conditions.

6.6. Future Growth

Past spills and current shipping operations related to tourism, mining operations and ferry transport are the most likely sources of petroleum hydrocarbons to Skagway Harbor. Marine cargo movements in the future will continue to be driven, primarily, by these industries. Although there is no definitive source identified for these impairments, existing operations in the harbor are not likely to be significantly impacting the area. Therefore future growth is not anticipated to affect impairment status in the harbors. In addition, discharges of petroleum hydrocarbons are not allowed under current NPDES permits in the study area. If future activity is proposed in Skagway Harbor that will entail discharge of petroleum hydrocarbons beyond the water quality standards, the TMDL may be revised to include modified WLAs. Possible revision of the WLA in this TMDL will depend on analysis of relevant factors at that time.

6.7. Daily Load

The TMDL for Skagway Harbor is presented as an allowable maximum concentration of PAHs in sediment. The allowable concentration is applicable at all times and can therefore be applied on a daily basis. This is consistent with the requirement to express TMDLs on a daily time increment.

7. Implementation

Available data show elevated levels of petroleum hydrocarbons in Skagway Harbor sediments located in the vicinity of the Ore and Broadway Ferry docks. A large number of commercial and private vessels frequent the study area on a year-round basis and require services, including fueling, waste disposal services, and long-term moorage. These dock and harbor operations all have the potential to release petroleum hydrocarbons and impact water quality. The petroleum already attached to bottom sediments in the harbors could be allowed to naturally attenuate over time through burial by "clean" sediments or physically removed. However, the benefits or necessity of dredging would require careful consideration because of the potential for damaging habitat and aquatic organisms. Dredging can damage the habitat of benthic macroinvertebrates and might directly kill some organisms. The process of stirring up suspended sediments during dredging can also damage the gills and/or sensory organs of benthic macroinvertebrates and fish. In addition, the resuspension of contaminated sediments provides organisms with additional exposure to petroleum derivatives. Therefore, restoration will likely rely on natural recovery as contaminated sediments are buried by "clean" sediment and on the control of any additional existing or future inputs. Therefore, the implementation of these TMDLs will focus on the continued management of shipping and docking operations to prevent petroleum products from entering Skagway Harbor.

Existing management plans and best management practices (BMPs) provide a framework to minimize the risk of petroleum hydrocarbon pollution. Currently, privately owned and operated docks are responsible for developing individual BMP programs if they meet certain risk thresholds for petroleum spills. The City of Skagway and two private entities, Petro Marine and PARNCWPYRR, operate docks in the study area. In the future, Skagway Harbor stakeholders should consider developing uniform BMPs for all docks and harbors. This would allow for a consistent regulatory environment and easier implementation and enforcement.

In addition to the current impairment by petroleum products, Skagway Harbor has a history of impairment or threat by metals contamination. The area has a long history of mining activity, including the shipping of ore concentrates extracted from the Faro Mine, a galena mining and concentration facility that produced low-grade zinc and lead. Concentrate ores also contained concentrations of arsenic, cadmium, copper, and mercury. Ores were transported to the Skagway facility by rail and subsequently stored and transferred to ships. High winds are common in Skagway and airborne ore dust resulted from many of the early shipping, storage, and transfer procedures (ADEC 1992). Recent data indicates that levels of historically accumulated metals in the harbor sediments are declining and metals are no longer considered to be the primary cause of toxic conditions in harbor sediments. However, in isolated samples, metals do still exist in harbor sediments in excess of NOAA sediment guidelines. Management efforts should focus on managing any additional or new inputs of metals. All permitted uses must adhere to existing Alaska Water Quality Standards and may consider NOAA sediment guidelines to prevent sediment concentrations from returning to levels that would contribute to further impairment of the benthic environment.

7.1. Management of Sources of Petroleum

Skagway Harbor experiences a high level of marine vessel traffic associated with tourism, mining operations, and ferry transport. As a result, oil and fuel spills to surface waters have the potential to occur. Major fuel spills can happen during fueling and fuel transfer operations, while vessels storing fuel oil on decks in drums and operating portable equipment with external fuel tanks can cause minor spills. The release of oily bilge water is also threat because boats moored at a facility for a long period will accumulate excessive water in their bilges. Many bilges are pumped automatically based on water level, and if the bilges are not properly inspected and maintained by owners and operators, these discharges often contain oily mixtures. Even small amounts of oil or fuel, if spilled, can have a detrimental impact on the environment. General methods for reducing impacts from oil pollution associated with marine shipping and docking operations include:

- Employing strict operating and safety procedures wherever large quantities of petroleum products are involved. Alarm systems and security measures should be developed for all facilities handling oil to prevent spills caused by carelessness, vandalism, or sabotage.
- Operations conducted near oil storage areas should be conducted in a manner that does not contribute to the likelihood of an oil spill.
- Siting oil storage facilities a sufficient distance away from any open water, if possible, and constructing impermeable containment dikes that could contain the contents of the storage facilities in the event of a leak or catastrophic failure. Storage facilities should not be located in sensitive habitats, areas of high fish and wildlife concentrations, or in geophysically unstable areas.
- Designing tanker docks and fueling facilities with automatic shut off systems and back-up safety systems.
- Effective oil spill containment and cleanup plans should be prepared and containment and cleanup equipment should be stationed in the region. Trained personnel should be available at all times to operate the equipment. Anchor points for oil exclusion booms should be identified at the mouths of all important fish streams, lagoons, and bays. Only approved chemical dispersants should be used to protect species and habitats sensitive to the physical effects of oil pollution.

Docks and harbors in Skagway Harbor are operated both publicly and privately. Operations at publicly owned and operated docks—the Small Boat Harbor and the east end of the Ferry Dock—are managed by the City of Skagway. Currently the City of Skagway has no BMP plan in place to minimize the risk of petroleum spills at these docks (personal communication , M. O’Boyle, Skagway Harbor Master, January 6, 2010). This is likely because they do not provide fueling services and the risk of petroleum spills is very low.

Private docks in the harbor are operated by two entities. PARNCWPYRR operates three private docking facilities through a lease with the City of Skagway (Ore Dock, Broadway Dock, and the White Pass Rail Road Dock). The west portion of the Ferry Dock, is managed by the Alaska Marine Highway and operated by Petro Marine, Skagway, serves as the primary distributor of fuels to charter vessels, commercial boat traffic, Alaska state ferries, and fuel tank trucks that operate in the study area. It has a 4.6 million gallon storage capacity and distributes fuels at a rate of 450 gallons per minute (personal communication, T. Cochran, Petro Marine, January 6, 2010).

Private owners and operators of facilities that store or use oil, including docks and harbors, have management responsibilities established by the Federal Oil Pollution Prevention regulations (40 CFR 112. Management practices at this facility are guided by Facility Response Plans (FRPs), Spill Prevention, Control, and Countermeasure (SPCC) plans, or other contingency plans based on the nature of its operations.

The SPCC rule is the basis of EPA’s oil spill prevention program. The SPCC rule requires that all regulated facilities have a fully prepared and implemented SPCC Plan. SPCC plans must be certified by a licensed professional engineer and the facility must implement the Plan, including carrying out the spill prevention and control measures established for the type of facility or operations, such as measures for containing a spill (e.g., berms).

The FRP program is designed to ensure that certain facilities have adequate oil spill response capabilities. An FRP is a plan for responding, to the maximum extent practicable, to a worse case discharge, and to a substantial threat of such a discharge, of oil. The Plan also includes responding to small and medium discharges as appropriate (EPA 2002). According to the OPA, an owner or operator of a "substantial harm" facility must develop and implement an FRP. A "substantial harm" facility is a facility that, because of its location, could reasonably be expected to cause substantial harm to the environment by discharging oil into or on navigable waters or adjoining shorelines. A dock meets this standard if the facility transfers oil over water to or from vessels and has a total oil storage capacity greater than or equal to 42,000 gallons (EPA 2002). FRPs must be reviewed and updated periodically to reflect changes at the facility where the change may materially affect the response to a worst case discharge (EPA 2002).

7.2. Management of Sources of Metals

In addition to any education and source control activities focusing on preventing or reducing the input of petroleum products, management activities for Skagway Harbor should also integrate activities focused on the control of metals. Mining related shipping operations in Skagway Harbor resumed in late 2007 after the Skagway Ore Terminal was reactivated by Alaska Industrial Development and Export Authority (AIDEA). According to AIDEA's web site they are continuing active discussions with mining companies for potential use of the Skagway Ore Terminal. Any future operations at the ore terminal should implement practices to minimize the release of airborne ore dust that could potentially accumulate in Pullen Creek and other nearby waterbodies and surrounding soils. BMPs and controls can minimize fugitive dust from sources such as haul truck activities and ore and concentrate storage, handling, and loading. Examples of recommended practices include:

- During transport and unloading activities, haul trucks should be covered with a hard cover reducing potential for fugitive dust generation from the payload.
- Onsite ore storage should be in an enclosed storage area with four walls and a roof to protect the ore piles from exposure to precipitation and reduce the impact of wind.
- Ore transfer by loading equipment or conveyor should be performed within enclosed buildings.
- Floor and vehicle cleaning plans should be implemented to minimize the transfer of ore dust from controlled, enclosed buildings to outside areas exposed to wind and precipitation.

7.3. Recommendations

Existing management plans and BMPs provide a framework to minimize the risk of petroleum hydrocarbon pollution. More focus should be placed on enacting, educating, and enforcing BMPs at docks. Together with ADEC, this effort likely will require interface with multiple agencies, groups, and businesses, such as the Alaska Department of Spill Prevention and Response, Alaska Department of Fish and Game, USCG, The City of Skagway Harbor Harbormaster, Petro Marine, and the PARNCWPYRR.

In addition, monitoring efforts in the harbor should continue to determine whether natural recovery is occurring and concentrations of petroleum contaminants are decreasing over time due to natural sedimentation processes if the system is not disturbed. Monitoring will allow ADEC to track the progress of changes in water and sediment and determine whether acceptable progress is being made. Monitoring should also be expanded to include characterization of sediment quality in the East Harbor and further evaluation of potential stormwater sources.

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